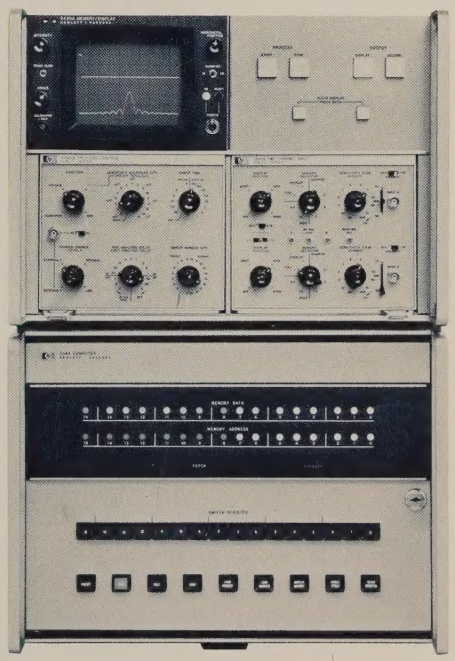
OPERATING MANUAL

SIGNAL ANALYZER SYSTEM

5481A



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CERTIFICATION

The Hewlett-Packard Company certifies that this instrument was thoroughly tested and inspected and found to meet its published specifications when it was shipped from the factory. The Hewlett-Packard Company further certifies that its calibration measurements are traceable to the U.S. National Bureau of Standards to the extent allowed by the Bureau's calibration facility.

WARRANTY AND ASSISTANCE

All Hewlett-Packard products are warranted against defects in materials and workmanship. This warranty applies for one year from the date of delivery, or, in the case of certain major components listed in the operating manual, for the specified period. We will repair or replace products which prove to be defective during the warranty period provided they are returned to Hewlett-Packard. No other warranty is expressed or implied. We are not liable for consequential damages.

Service contracts or customer assistance agreements are available for Hewlett-Packard products that require maintenance and repair on-site.

For any assistance, contact your nearest Hewlett-Packard Sales and Service Office. Addresses are provided at the back of this manual.

SIGNAL ANALYZER SYSTEM
5481A

ALL SERIALS

This manual applies directly to all standard Hewlett-Packard Model 5481A Signal Analyzer systems. See SYSTEM IDENTIFICATION, Paragraph 1-10.

SPECIAL SYSTEMS

The information required to relate this manual to special modifications is supplied on insert sheets. If this information is missing, contact any HP Sales and Service office, giving full specification number, system name, and serial number.

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MANUAL CONTENT AND ORGANIZATION

This is a system operating manual only. Information on software and servicing is located in separate manuals. Operating, software, and service information is divided among the manuals as follows:

OPERATING MANUAL:
- General Information
- Installation Procedures
- System Check Out Procedures
- Packaging Information
- Operating Information

SOFTWARE MANUAL:
- General Information
- System Software
- Library

SERVICE MANUAL:
- Theory of Operation
- Troubleshooting Procedures
- Replaceable Parts
- Schematic Diagrams and Waveforms

HOW TO ORDER

To order an operating and service manual, contact the nearest Hewlett-Packard Sales and Service office. Give complete model, name, and serial number (see Paragraph 1-10 for serial number system).

MANUAL COMMENTS

Comments on this manual are welcome at any Sales and Service office.

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SECTION I

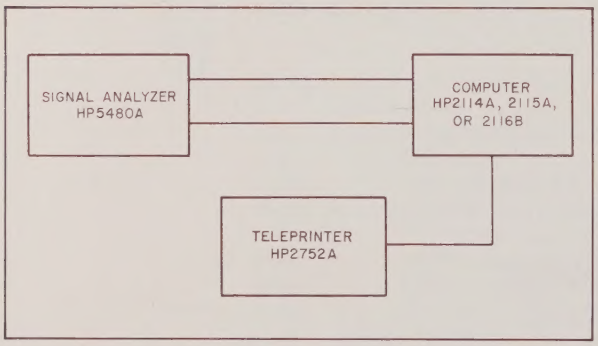
GENERAL INFORMATION

1-1. DESCRIPTION

1-2. The 5481A Signal Analyzer System processes data provided by a 5480A Signal Analyzer and displays the results on the CRT of the 5480A Memory/Display Unit.

1-3. The 5481A System utilizes a direct interface between an HP 2114A, 2115A or 2116B series Computer and the 5480A Signal Analyzer. See Figure 1-1. This interface provides the capability of using the 5480A as an I/O (Input/Output) device for the computer. The primary purpose of the 5480A is to extract a repetitive data signal from noise for investigation or analysis. The 5480A Memory/Display Unit provides a visual display of the averaged time domain signal. However, in some applications time domain information is not enough. Further processing, e.g. converting time domain data to frequency domain (by means of Fourier Transform) is necessary.

Figure 1-1. 5481A Signal Analyzer System



1-4. A signal can be averaged on the 5480A Signal Analyzer and then outputted to the computer for further processing. The results of this extended processing may then be taken from the computer and displayed on the 5480A Memory/Display Unit CRT. As a component of an automatic system, computer subroutines can control front panel pushbuttons of the 5480A Signal Analyzer and the MEMORY SELECTOR switch.

1-5. The basic 5481A Signal Analyzer System consists of an HP 2114A Computer (with 4K memory and a 2752A Teleprinter), a 5480A Signal Analyzer (includes: 5480A Memory/Display Unit, with 5485A and 5486A Plug-in Units), two interface cards and cables, and system software.

1-6. APPLICATIONS

1-7. The 5481A System has applications in the following fields: optics, nuclear magnetic resonance (NMR) and pulsed NMR spectroscopy, time domain reflectrometry, biomedical, testing and calibration, and vibration.

1-8. EQUIPMENT SUPPLIED

1-9. All equipment supplied with the 5481A System and any additional equipment that has been ordered is listed on an insert sheet included with this manual. The system is complete with all the equipment necessary to operate it.

1-10. SYSTEM IDENTIFICATION

1-11. The 5481A System components are uniquely identified by a serial number. The entire 5481A system is assigned a number prefixed 05481-90XXX. This number is on the insert sheet and should be included in any correspondence concerning the system.

1-12. ACCESSORIES

1-13. Other equipment or accessories can be ordered in addition to standard system components, e.g. an HP 2737A Photoreader or an HP 2753A High Speed Tape Punch may be ordered to increase the speed of data transfer to and from the computer.

1-14. SPECIFICATIONS

1-15. For detailed information on system instruments (2114A, 2115A, or 2116B Computer and 5480A Signal Analyzer) refer to the Operating and Service Manuals for those instruments. Technical information for the interface cards is located in the 5481A System Service Manual.

1-16. SYSTEM INSTRUMENTS (SUBSYSTEMS)

1-17. Computer Subsystem

1-18. The HP 2114A, 2115A, or 2116B series Computers are stored program type with general purpose capabilities (mathematical and instrument interface). Program storage permits rapid access of any location in memory. The computer's role in the 5481A System operation is to process data from the 5480A Signal Analyzer and return the results, to be displayed on the 5480A Memory/Display Unit CRT.

1-19. 5480A Subsystem

1-20. The HP 5480A Signal Analyzer is basically a buffered memory oscilloscope equipped with a digital processor and hardwired routines for processing data to be displayed on the CRT of the 5480A Memory/Display Unit.

1-21. The 5480A Signal Analyzer uses digital processing to extract a repetitive data signal from noise. It can also perform summation, averaging, multichannel scaling and frequency or time histograms. In the operation of the 5481A System we will be primarily concerned with the Averaging mode.

SECTION II

INSTALLATION

2-1. UNPACKING AND INSPECTION

2-2. If any of the shipping cartons are damaged ask the carrier's agent to be present when the system components are unpacked. Inspect all system components for damage (scratches, dents, broken knobs, etc). If any of the system components are damaged or fails to meet its specifications (performance checks for individual system instruments can be found in their respective manuals), notify carrier and the nearest HP Sales and Service office immediately (offices are listed at the back of this manual). Retain the shipping cartons and padding materials for the carrier's inspection. The Sales and Service office will arrange for repair or replacement of any system instruments without waiting for the claim against the carrier to be settled.

2-3. POWER CONNECTION

2-4. Power connection to system instruments is outlined in the following paragraphs.

2-5. 5480A Signal Analyzer

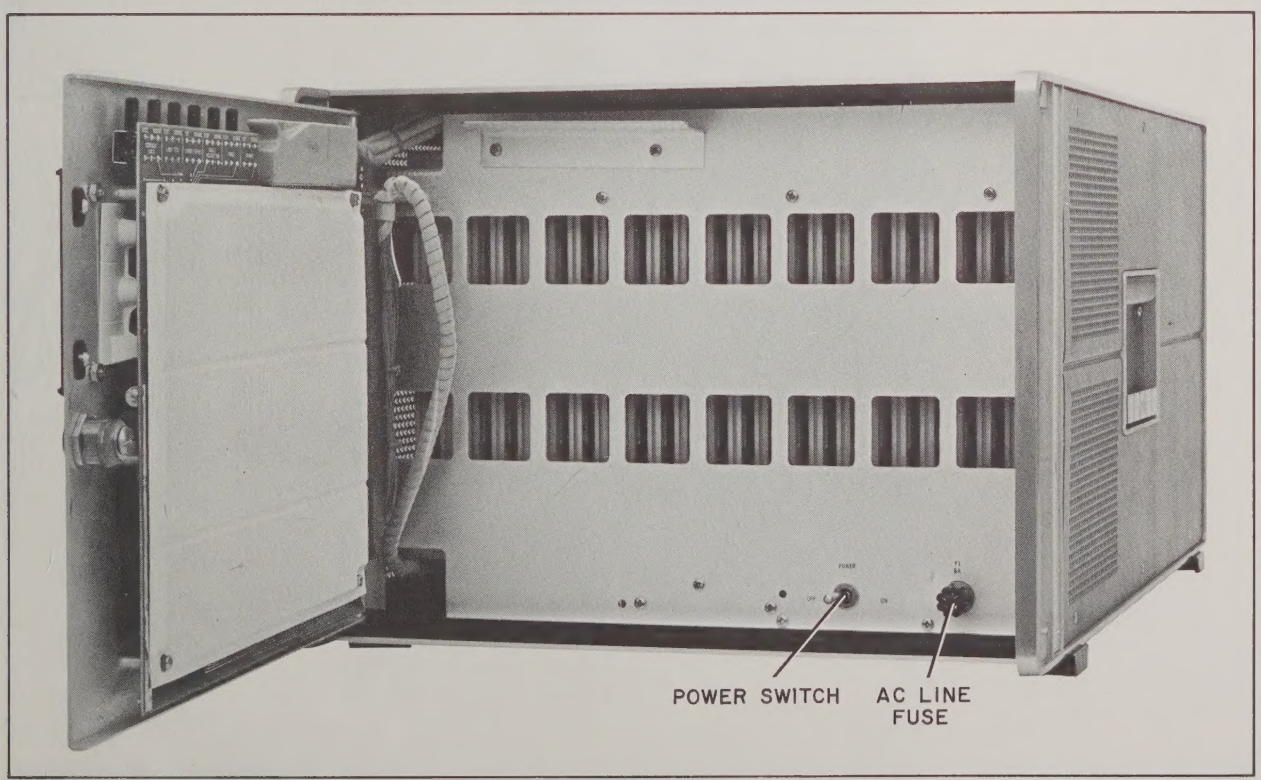
2-6. Set line voltage switch (on rear panel) to expose the number (115 or 230) corresponding to the line voltage used to operate instrument. Be sure correct fuse is installed for operating voltage selected; for 115 Vac, use 2.5A slow blow; for 230 Vac, use 1.25A slow blow. With power cord, connect instrument to 115 or 230 Vac 50-60 Hz power line.

2-7. 2114A Computer

2-8. Connect receptacle end of line power cord to mating connector on rear panel. Turn receptacle cw to lock it in place. To remove, turn ccw and pull straight out. Connect other end of power cord to 115 Vac 50-60 Hz power line. The AC LINE FUSE and POWER switch are located behind the front panel, see Figure 2-1. To open front panel, insert key in lock and turn ccw 90° and open to the left. The AC LINE FUSE should be 15A slow blow.

2-9. 230 Volt Operation. To operate 2114A Computer from 230 Vac, a separate step down transformer is necessary.

Figure 2-1. 2114A Computer (Front Panel Open)



2-10. 2115A Computer

2-11. The 2115A Computer is in two parts, the 2115A Mainframe and the 2161A Power Supply. Connect the two large cables coming from rear of 2115A Mainframe to mating connectors (J2 and J3) on 2161A Power Supply rear panel. Connect receptacle end of line power cord to J1, AC POWER jack on 2161A rear panel. Turn receptacle cw to lock it in place. To remove, turn it ccw and pull straight out. Connect other end of power cord to 115 Vac 50-60 Hz power line. The line fuse (F1) is next to the AC POWER jack. Fuse should be 15A slow blow for 115 volt operation.

2-12. 230 Volt Operation. WARNING: Disconnect power before performing procedure below. To operate from 230 Vac proceed as follows:

a. Remove top cover from 2161A Power Supply.

b. Located in the front right center area (as viewed from the top with the front panel facing you) is a terminal strip protected by a cover labeled "DANGER HIGH VOLTAGE" (see Figure 2-2). Remove cover; on the left side of the terminal strip are two jumpers. Remove both jumpers and reconnect them (place one on top of the other) between the two heavy black wires (marked 2, 3) at center of terminal strip.

c. Tighten all screws and replace protective cover.

d. Replace top cover and change Line Fuse to 7.5A slow blow.

e. The 2161A Power Supply is now ready for 230 Vac operation.

2-13. The 2115A POWER switch is located at the extreme right side of Mainframe front panel.

2-14. 2116B Computer

2-15. Connect receptacle end of line power cord to mating connector on rear panel. Turn receptacle cw to lock it in place. To remove, turn it ccw and pull straight out. Connect other end of power cord to 115 Vac 50-60 Hz power line. The AC LINE FUSE is accessible from the rear of the computer on the right hand side (as viewed from rear of computer) of the I/O cable slot, see Figure 2-3. The LINE FUSE holder is located about 6 inches inside and half way between the right blower motor and right side frame. The fuse holder is mounted upside down. To remove fuse, rotate cap a quarter turn to the left and pull straight down. Fuse should be 15A slow blow for 115 Vac operation.

Figure 2-2. 2161A Power Supply (Top view, cover removed)

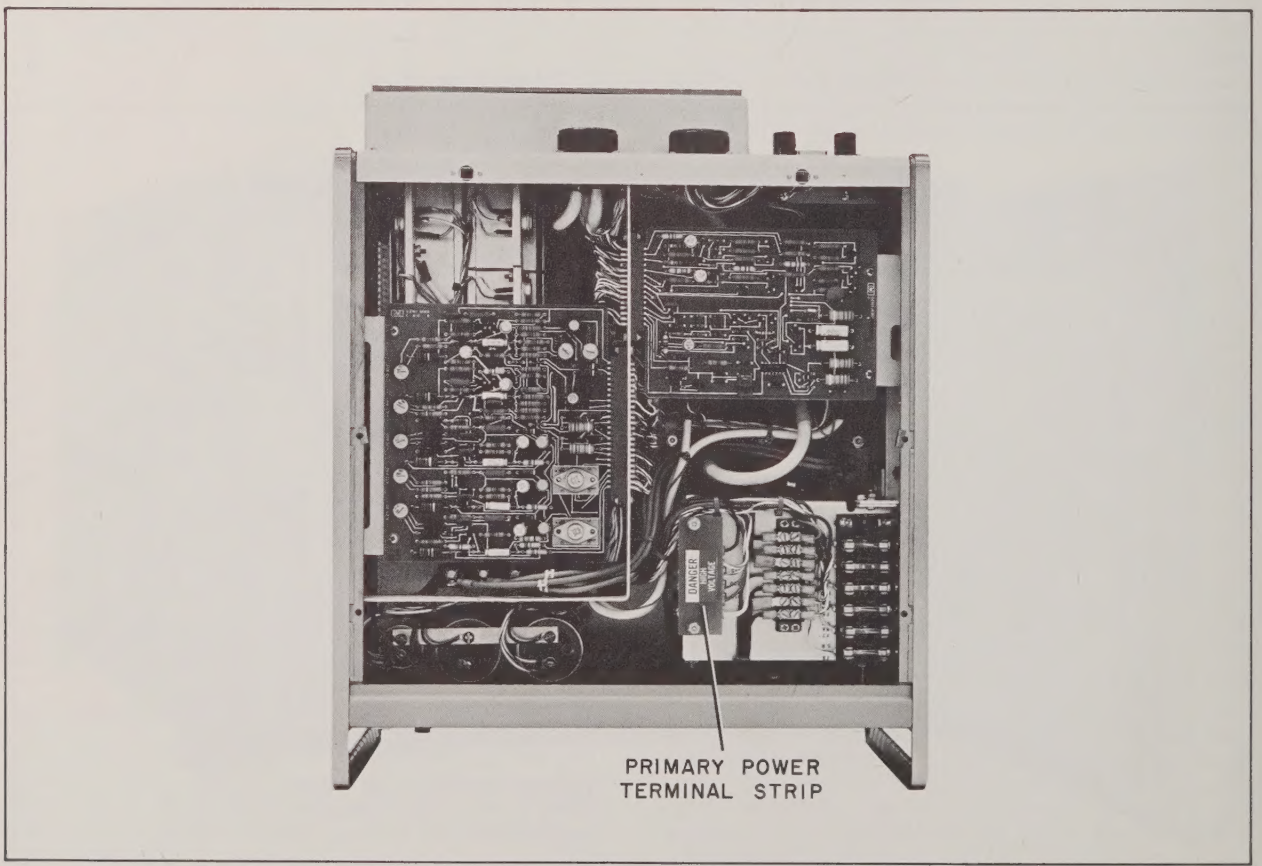


Figure 2-3. 2116B Computer (Rear Panel)

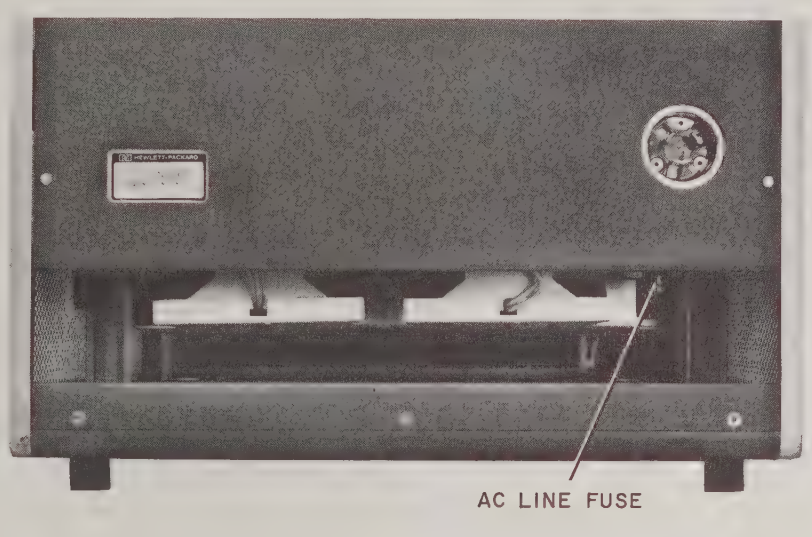
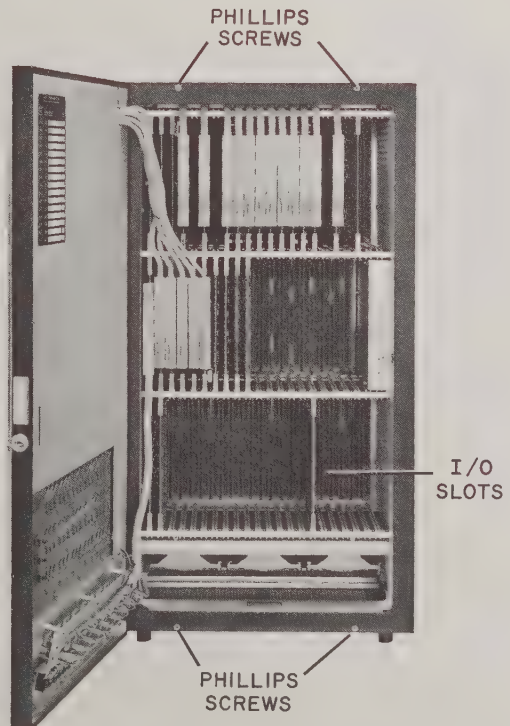


Figure 2-4. 2116B Computer (Door Open)



2-16. 230 Volt Operation. WARNING: Disconnect power before performing procedure below. To operate from 230 Vac proceed as follows:

a. Open Computer door by inserting key into lock on right side of door. Turn key ccw 90° (as viewed from right side of Computer) and open door to the left.

b. Located at the top and bottom of the black flange surrounding the card cage, are pairs of phillips screws; see Figure 2-4. Remove screws and pull card cage straight out until it locks.

c. Swing card cage to the right 90°, see Figure 2-5.

d. At the rear of the cabinet is a protective cover held on by 6 nylon fasteners. Release fasteners by pulling plungers straight out until they snap (it may be necessary to use a flat bladed screwdriver to pry plungers out).

e. Remove protective cover.

f. Following directions on cover, remove and reconnect jumpers on primary power terminal strip for 230 Volt operation.

g. Tighten all screws on terminal strip and replace protective cover by positioning cover in place and pushing fastener plungers in until they snap.

h. Rotate card cage left 90° and release rail latch by pressing release tabs together (see Figure 2-5), at the same time push card cage back into cabinet.

i. Replace AC LINE FUSE with 7.5A slow blow.

j. Computer is now ready for 230 volt operation.

2-17. RACK MOUNTING

2-18. Instructions for rack mounting are included in the rack mounting kits of each system instrument.

2-19. OPERATING ENVIRONMENT

2-20. The following are ambient temperature and humidity limits for 5481A System instruments.

Note

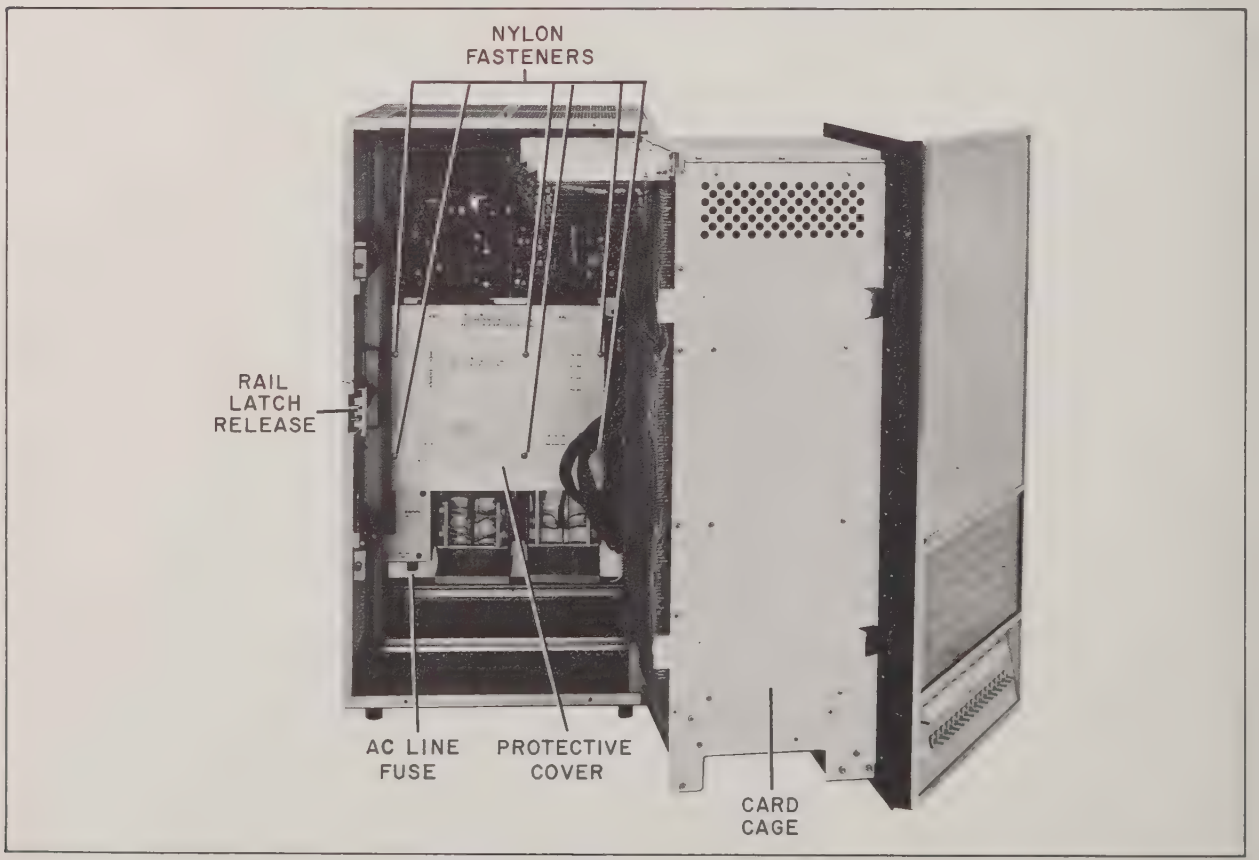
If system instruments are operated in a rack or other similar enclosure be sure ambient temperature does not exceed maximum specified for equipment.

2114A/2115A Computer
Temperature: +10° to +40°C (+50° to +104°F).
Humidity: To 80% at 40°C.

2116B Computer
Temperature: From 0° to +55°C (+32° to +131°F).
Humidity: To 95% at 40°C.

5480A Signal Analyzer
Temperature: From 0° to +55°C (+32° to +131°F).
Humidity: To 95% at 40°C.

Figure 2-5. 2116B Computer (Card Cage Out)



2-21. SYSTEM INSTRUMENT INTERCONNECTION

2-22. Procedures for installing interface cards and interconnecting cables are outlined below. System is normally shipped with interface cards installed in computer.

2-23. 2114A Computer

a. Remove top cover.

b. Insert interface cards into their assigned I/O slots, see Figure 2-6 and Table 2-1 (refer to insert sheet for I/O channel number assignments for your system).

Table 2-1. I/O Channel No. VS I/O Slot No. 2114A Computer

I/O Slot No.	I/O Channel No.
A16	17
A17	16
A18	15
A19	14
A20	13
A21	12
A22	11
A23	10

c. Install printed circuit connectors of I/O cables on their respective interface cards in the computer.

d. Plug connector at opposite end of 05481-60002 cable (connected to Control interface card 05481-60001) into connector B on rear panel of 5480A Signal Analyzer, see Figure 2-7.

e. Plug connector at opposite end of 05481-60003 cable (connected to Data Buffer interface card 05481-60000) into connector C2 on rear panel of 5480A Signal Analyzer, see Figure 2-7.

f. Replace computer top cover.

g. Before operating Teleprinter or other computer peripheral devices refer to their respective manuals for set-up and operating procedures.

2-24. 2115A Computer

a. Remove top cover from 2115A Mainframe.

b. Insert interface cards into their assigned I/O slots, see Figure 2-8 and Table 2-2 (refer to insert sheet for I/O channel number assignments for your system).

c. Install printed circuit connectors of I/O cables on their respective interface cards in the computer.

Figure 2-6. 2114A Computer (Top View, Cover Removed)

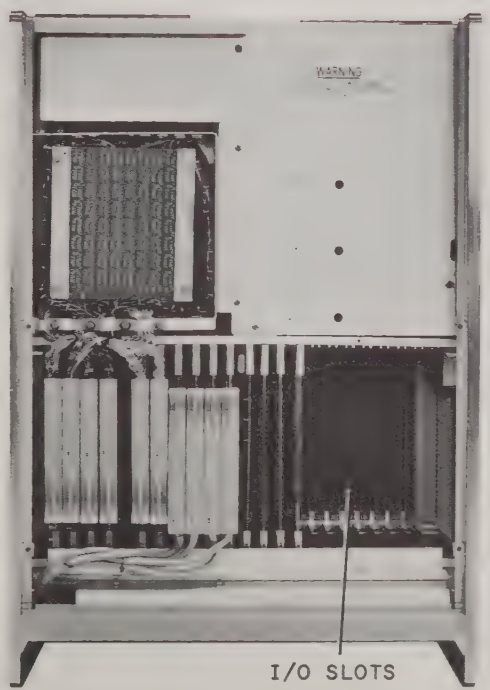


Figure 2-7. 5480A Signal Analyzer (Rear Panel)

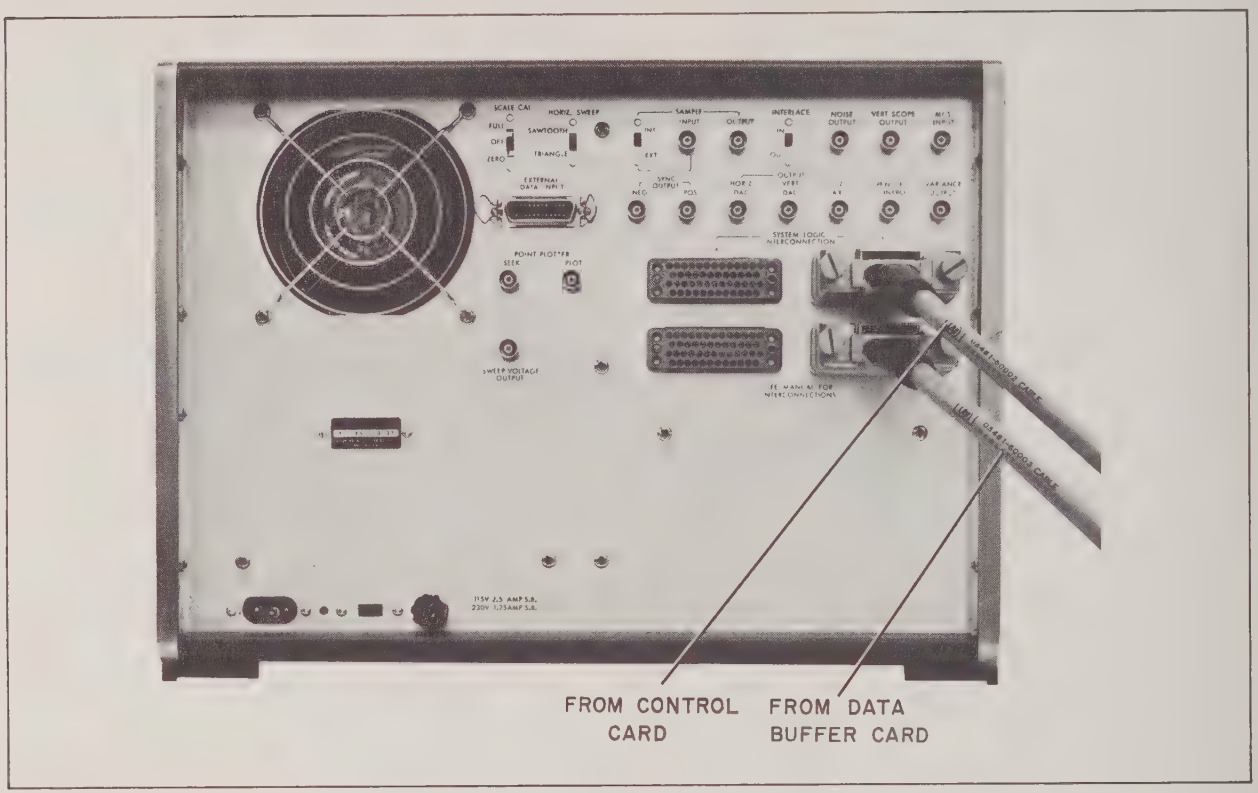


Table 2-2. I/O Channel No. VS I/O Slot No. 2115A Computer

I/O Slot No.	I/O Channel No.
121	10
120	11
119	12
118	13
117	14
116	15
115	16
114	17

d. Plug connector at opposite end of 05481-60002 cable (connected to Control interface card 05481-60001) into connector B on rear panel of 5480A Signal Analyzer, see Figure 2-7.

e. Plug connector at opposite end of 05481-60003 cable (connected to Data Buffer interface card 05481-60000) into connector C2 on rear panel of 5480A Signal Analyzer, see Figure 2-7.

f. Replace top cover of 2115A Mainframe.

g. Before operating Teleprinter or other computer peripheral devices refer to their respective manuals for set-up and operating procedures.

2-25. 2116B Computer

a. Open computer door by inserting key in lock on right side of door. Turn key ccw 90° (as viewed from right side of computer) and open door to the left.

b. Insert interface cards into their assigned I/O slots, see Figure 2-4 and Table 2-3 (refer to insert sheet for I/O channel number assignments for your system).

Table 2-3. I/O Channel No. VS I/O Slot No. 2116B Computer

I/O Slot No.	I/O Channel No.
203	10
204	11
205	12
206	13
207	14
208	15
209	16
210	17
211	20
212	21
213	22
214	23
215	24
216	25
217	26
218	27

c. Pass printed circuit connectors of I/O cables through access slot at rear of computer and install them on their respective interface cards.

d. Plug connector at opposite end of 05481-60002 cable (connected to Control interface card 05481-60001) into connector B on rear panel of 5480A Signal Analyzer, see Figure 2-7.

e. Plug connector at opposite end of 05481-60003 cable (connected to Data Buffer interface card 05481-60000) into connector C2 on rear panel of 5480A Signal Analyzer, see Figure 2-7.

f. Close computer door.

g. Before operating Teleprinter or other computer peripheral devices refer to their respective manuals for set-up and operating procedures.

2-26. SYSTEM CHECK OUT PROCEDURE

2-27. To check system operation refer to system tape operating procedures outlined in Section III.

2-28. STORAGE AND SHIPMENT

2-29. To protect electronic equipment during storage and shipment always use best packing methods available. Hewlett-Packard Sales and Service offices can provide packing material such as that used for original factory packaging. Contract packaging companies in many cities can provide dependable custom packaging on short notice. Following are two recommended packaging methods.

2-30. RUBBERIZED HAIR. Cover painted surfaces of instrument with protective wrapping paper. Pack instruments securely in strong corrugated container (350 lb/sq. in. bursting test) with 2 inch rubberized hair pads placed along all surfaces of instrument. Insert fillers between pads and container to insure a firm fit.

2-31. EXCELSIOR. Cover painted surfaces of instrument with protective wrapping paper. Pack instrument in strong corrugated container (350 lb/sq. in. bursting test) with a layer of excelsior about 6 inches thick packed firm against all instrument surfaces.

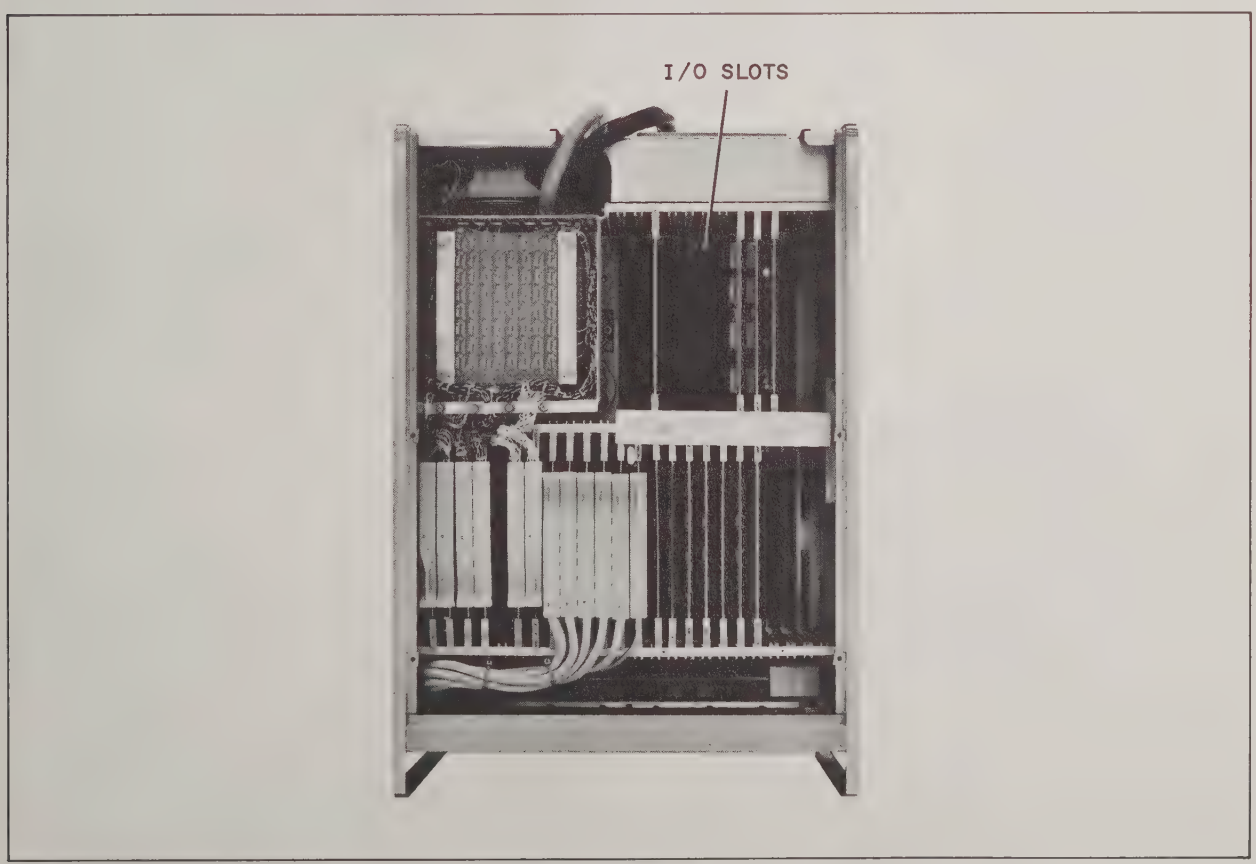
2-32. ENVIRONMENT. Conditions during storage and shipment should be limited as follows:

a. Maximum temperature: +167°F (+75°C).

b. Minimum temperature: -40°F (-40°C).

c. Maximum altitude: 25,000 feet (10.8 in Hg).

Figure 2-8. 2115A Computer Mainframe (Top View, Cover Removed)



SECTION III

OPERATION

3-1. INTRODUCTION

3-2. This section describes in more detail, instruments that make up the 5481A System. A description of controls and connectors for system instruments and operation of the 5481A System tape is also included. Operating information for system software is located in the 5481A Software Manual.

3-3. SYSTEM INSTRUMENTS (SUBSYSTEMS)

3-4. Computer

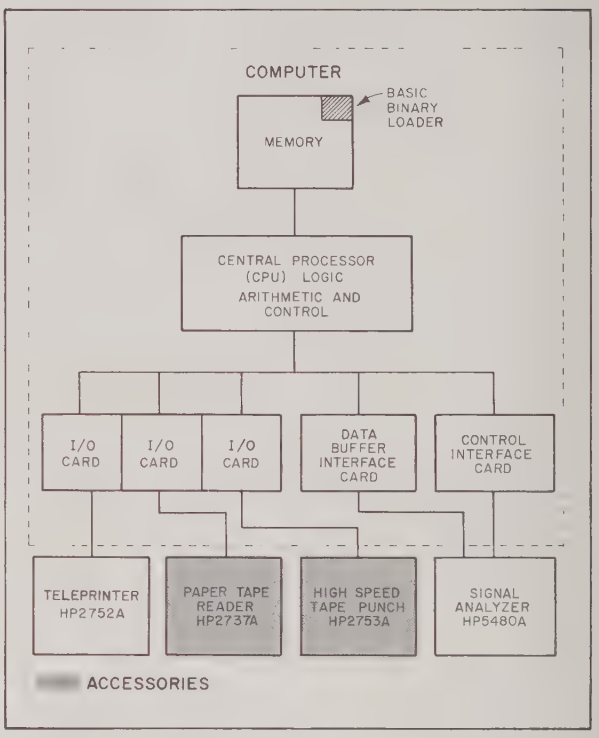
3-5. Although the 5481A Signal Analyzer System is basically an averaging instrument, it derives much of its versatility and accuracy from the computer which has been integrated into the total system so that making measurements requires no knowledge of computer operation beyond following simple instructions. There is no need to learn programming or worry about damaging the computer. About the worst thing an operator can do is to erase some of the computer's memory. Since storage is temporary anyway, memory can be restored by loading a program tape. The HP 2114A, 2115A, and 2116B series Computers are stored programmed type with general purpose capabilities (mathematical and instrument interface). Program storage permits rapid access of any location in memory. The basic elements of the computer are shown in Figure 3-1. Instructions and data are stored in the computer's "core" memory. The HP Model 2114A or 2115A Computers may have 4096 (4K) or 8192 (8K) words of memory, while the Model 2116B may have 8192 or 16,384 (16K) words of memory. Each word is a 16-bit number. In computer terminology, a "word" is a unit of data which is transferred into or out of memory.

3-6. The computer's core memory is similar to a post office, with each post office box representing a word of memory. Each memory location (box) has an address (box number) and each location can hold a piece of information (letter). Thus, a word of memory can be located by its address.

3-7. Memory information may be changed during program loading and execution. Stored in a deep dark corner of memory is a 64 word program called the "Basic Binary Loader". This program instructs the computer to load punched paper tapes (loaded by the Teleprinter tape reader or a photoreader) that contain computer instructions or data.

3-8. The storage area of the Basic Binary Loader is protected (except during program loading) by the Computer LOADER switch on the front panel (located behind front panel on 2114A, see Figure 3-5). This protection prevents the 64 memory locations, containing the Loader program, from being accessed during program execution. If a program is run with the LOADER switch set to ENABLED, it's likely that some of the Loader program will be destroyed (erased). This is about the most serious operating error that can be made. The penalty being a few minutes of your time spent reloading the program via the SWITCH REGISTER (front panel switches).

Figure 3-1. Computer Block Diagram



3-9. The Central Processing Unit (CPU) does the arithmetic, makes decisions within the computer, and manages communications outside the computer. The central processor contains several registers made up of flip-flops. These registers temporarily store information the computer is currently working on. The front panel lights show the contents of these registers (on 2114A contents of A, B, and P registers are not displayed). The A and B registers hold numbers during the arithmetic or logical operations. On completion of each instruction, the P register contains the address of the next instruction to be "Fetched" out of memory. The M (MEMORY ADDRESS on 2114A) register holds the address of the memory cell being read or written into. The T (MEMORY DATA on 2114A) register contains the last word transferred in or out of memory during the preceeding memory cycle.

3-10. The computer operates sequentially following explicit instructions dictated by the program. For example, a typical cycle within a program starts by going to the P register to find the address of the next instruction. The 16 bit word at this address contains a coded instruction. After the instruction is executed, the central processor increments (adds one) to the P register so that it will contain the address of the next instruction. If the operation is an instruction to add a number in memory to the contents of the A register, then the CPU gets the number (the M register displays its location at this time), does the addition, puts the result in the A register, and then goes to the location specified by the P register to find the next instruction. The CPU uses the P register to remember where to find the next instruction while it does the arithmetic.

3-11. INSTRUMENT INTERFACES. The 5480A Signal Analyzer is connected to the computer through two special interface cards (Control card and Data Buffer card). These cards transmit data between the computer and the 5480A. The cards are installed in the I/O slots of the computer. One card handles control functions of the 5480A Signal Analyzer, the other is 24-bit data buffer for transmitting data between the computer and the 5480A. This allows on-line processing of data by the computer. After processing, results may be returned (via the Data Buffer card) and displayed on the 5480A Memory/Display Unit CRT.

3-12. I/O (INPUT/OUTPUT) DEVICES. The computer subsystem includes an HP 2752A Teleprinter. Other peripheral devices (e.g. an HP 2737A Photoreader, HP 2753A High Speed Tape Punch, etc.) are available. The HP 2737A Photoreader is used to read punched paper tapes. The HP 2753A High Speed Tape Punch is used to make permanent records that may be loaded into the computer at a later time. The HP 2752A Teleprinter operates as an I/O device for the computer and provides typewritten and punched tape records.

3-13. BINARY TAPE. All system software is in the form of binary paper tape. Each frame (row) of binary coded tape contains 8 binary digits (bits). Two successive frames fill one computer word. A hole in the tape represents a "one"; a blank is "zero". When the Basic Binary Loader loads a tape into memory, it stores two consecutive frames as one computer word. It also maintains a count of the number of bits in each block (a few inches of tape) of data and compares its count against a similar count punched into the tape at the end of each block. There is an accuracy or "checksum" on the entire program punching and reading process.

3-14. SOFTWARE. The word "software" refers to all the programs (computer instructions) which are needed to make the computer perform a specified task. The importance of software is in flexibility, the ability to change the computer's function by changing program instructions.

3-15. A number of programs are included in the 5481A System Tape which permit the operator to communicate with the system. These programs are combinations of subroutines, each performing a specific function. The operator may write his own measurement subroutines in ALGOL or FORTRAN as described in the 5481A System Software Manual. All measurement programs and subroutines for the 5481A System are documented in the System Software manual. They have been broken up into small routines so the function can be changed by simply removing or modifying subroutines.

3-16. COMPUTER DOCUMENTATION. Computer documentation consists of four volumes as follows:

a. Volume One: Specifications and Basic Operating Manual. This volume describes the full capabilities of the basic computer for which it is supplied (2114A, 2115A, or 2116B as applicable), including standard hardware options, standard software, and fundamental computer operation. This manual is intended both as a reference for users who are familiar with computer terminology and as a source for detailed definitions.

b. Volume Two: Installation and Maintenance Manual. This volume gives installation and maintenance information for the basic processor unit only. Its contents include installation, performance checks, theory of operation, logic and schematic diagrams, and a parts list.

c. Volume Three: Input/Output System Operation Manual. This volume describes the input/output structure and the standard input/output options (referenced by interface kit numbers) which form the basis for all standard HP computer systems. Procedures are given for connecting, operating and programming the standard computer input/output devices for which Hewlett-Packard designs interface cards. The information in these sections condenses operating procedures from the manuals of individual instruments and adds materials relating specifically to operation with the applicable HP computer. Maintenance information in these sections cover only the interface circuits and not the peripheral itself. Operating and Service manuals for peripheral devices are contained in the System Supplement.

d. Volume Four: Programmers Reference Manual. This volume consists of one or more 3-ring binders containing documentation for each item of software supplied with the computer. Both standard software programs and software specially originated for an individual user are fully described as to specifications and usage. A "Software System Installation Record" at the front of Volume Four lists all software furnished with the original shipment and provides an index to the supporting documents in Volume Four. Space is provided for noting changes and additions so that an up to date record can be maintained. Printed listings for standard programs are supplied as manual supplements in this volume. Programmer's reference manuals normally included in Volume Four are listed below:

(1) Assembler
(2) BASIC Language
(3) Basic Control System
(4) FORTRAN Language
(5) Program Library
(6) Standard Software Systems Operating Manual

(7) Symbolic Editor
(8) ALGOL Language

In addition to the four volumes shipped with each computer, a Computer Training Manual is also available. The training manual is designed to provide a general introduction to digital computers, how small computers operate and the concept of programming.

3-17. 5480A Signal Analyzer System

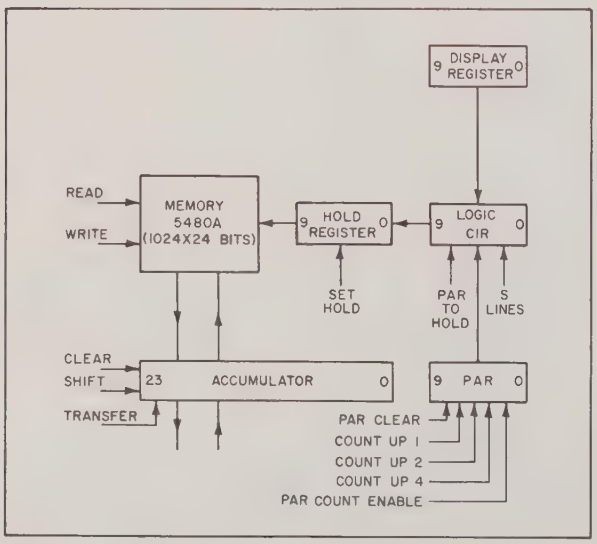
3-18. The HP 5480A Signal Analyzer is basically a buffered memory oscilloscope equipped with a digital processor and hardwired routines for processing data to be displayed on the CRT of the 5480A Memory/Display Unit.

3-19. AVERAGING AND SUMMATION FUNCTIONS. Analog input data is converted to digital form and processed according to routines selected by the FUNCTION switch. This data is stored in a magnetic core memory (1024 24-bit words). The Analyzer uses only 1000 words of the memory for processing and display of data. The CRT display is derived from 10 bits of each word processed or stored. The 10 bits used is determined by SENSITIVITY MULTIPLIER switch. The 5480A Signal Analyzer uses digital processing to extract a repetitive data signal from noise. It can also perform summation, averaging, multichannel scaling and frequency or time histograms. In the 5481A System we will be primarily concerned with the Averaging mode.

3-20. The three sections of the 5480A concerned with the computer interface are: the 24-bit accumulator, the memory, and the memory address registers; see Figure 3-2.

3-21. ACCUMULATOR. The accumulator register is the memory's only link with the outside world. All data to be stored in or extracted from memory must go through the accumulator.

Figure 3-2. 5480A Registers



3-22. MEMORY. The size of the 5480A memory is 1024 24-bit words and is a destructive read type memory. When data is read out of a memory location, the contents of that location are destroyed (erased). If it is desired to maintain the contents of a memory location after it is read, the data must be written back into that memory location. In the 5481A System the read and write functions of the 5480A memory are controlled by the computer through one of the interface cards.

3-23. MEMORY ADDRESS REGISTERS. The "hold" register, Figure 3-2, has the final control of selecting a memory location to be used. The "display" and "process address" registers preceed the hold register. Logic circuitry on the Control interface card in the computer determines which of these registers is to be switched into the hold register. The display register contains the address of data to be displayed on the CRT of the 5480A Memory/Display Unit. The process address register contains a memory address selected by the computer.

3-24. Theory of operation for the 5480A is located in Volume One, Section II of the maintenance manual for the 5480A Signal Analyzer System.

3-25. 5480A DOCUMENTATION. Documentation for the 5480A Signal Analyzer is listed under "Manual Content and Organization" at the front of the 5480A Operating Manual.

3-26. CONTROLS AND CONNECTORS

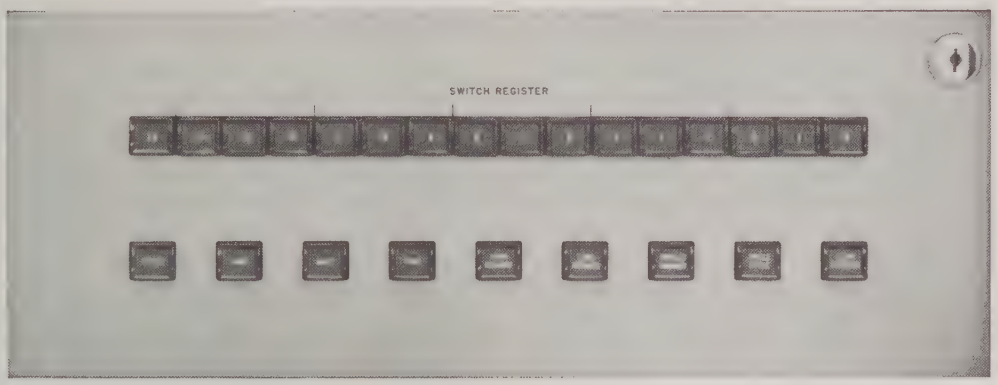
3-27. Computer

3-28. Front panel controls for the HP 2114A, 2115A, and 2116B Computers are shown in Figure 3-3. The controls of the 2115A and 2116B are nearly identical. The only difference is the type and location of the POWER switch. The 2115A has a toggle ON/OFF switch on the right side of its front panel. The 2116B has a pushbutton ON/OFF switch on the left side of the front panel. Both the 2115A and 2116B have toggle switches for the SWITCH REGISTER, all other controls are pushbuttons. The 2114A Computer has only proximity type sense switches on its front panel. Each switch requires only a touch for activation. The functions of the various switches are explained in the following paragraphs.

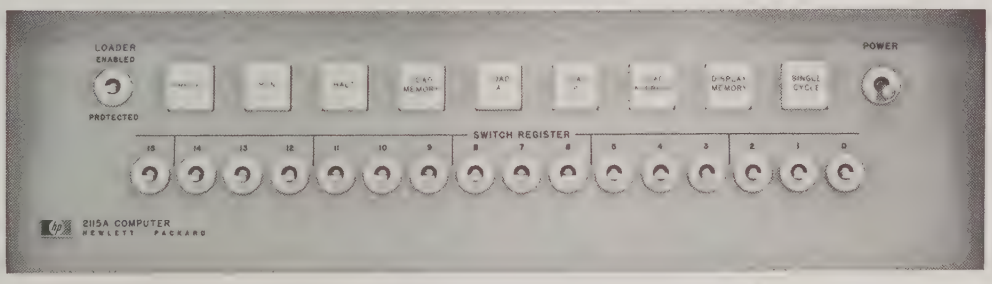
3-29. SWITCH REGISTER. Each HP computer has a row of 16 switches on its front panel to enable manual entry of data into the computer. The 2115A and 2116B have toggle switches. The up position is a "one" and the down position is a "zero". The 2114A switches are proximity sense switches which illuminate for "one" and remain dark for "zero". The 2114A CLEAR REGISTER switch resets the SWITCH REGISTER to all "zeros". The setting of the SWITCH REGISTER may be entered manually into the computer in the following ways:

a. With LOAD ADDRESS switch, contents of SWITCH REGISTER is loaded into the P and M (MEMORY ADDRESS on 2114A) registers simultaneously, thus, directing the computer to a specific memory cell.

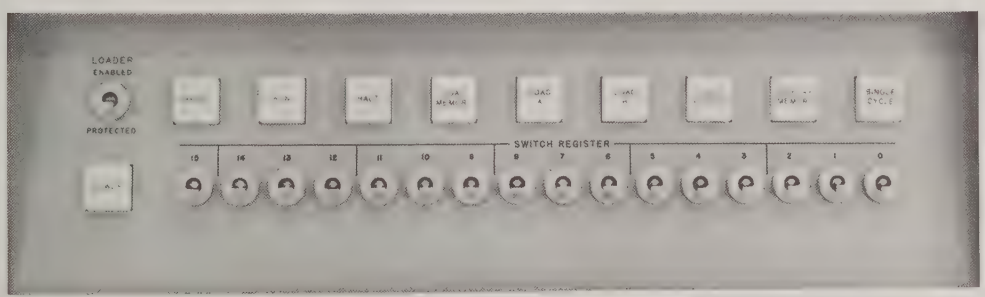
Figure 3-3. Computer Controls



2114A



2115A



2116B

b. With LOAD MEMORY switch, contents of SWITCH REGISTER is entered into memory cell specified by the M (MEMORY ADDRESS on 2114A) register thus permitting the user to change the contents of any memory cell.

c. On 2115A or 2116B Computer, with LOAD A or LOAD B switches, contents of SWITCH REGISTER is loaded into the A or B registers. On the 2114A Computer, to display the A and B register contents manually, press the CLEAR REGISTER switch, and LOAD ADDRESS switch, then the DISPLAY MEMORY switch. The contents of the A register will be displayed in the MEMORY DATA register. The contents of the B register will be displayed in the MEMORY DATA register when the DISPLAY MEMORY switch is pressed again.

3-30. SWITCH REGISTER settings are specified by the switch number (0 through 15) or by an octal number. Settings of individual switches might be indicated as "Set Switch 2 to one". For this reason switches are numbered (right to left) from 0 to 15 on the computer front panel. This method is usually used during measurements where the switches operate individually. For starting addresses and certain other operations, many switches may have to be set at one time, so an octal system is used; see Figure 3-4. The switches are divided in groups of three. Each group can be represented as an octal digit by assigning values of 4, 2, and 1 to each switch in the group (left to right) respectively. When a switch is set to one, it assumes the value assigned to it according to its position within the group. If all three switches in a group are set to one, the resulting octal number would be, 4 + 2 + 1 = 7. Other combinations are illustrated in Figure 3-4. The entire SWITCH REGISTER can be read as a 6 digit octal number. Switch 15 is read as either 1 or 0. On 2115A and 2116B, up switches represent "one", and down switches represent "zero". 102651_8 would be 1 000 010 110 101 001 binary.

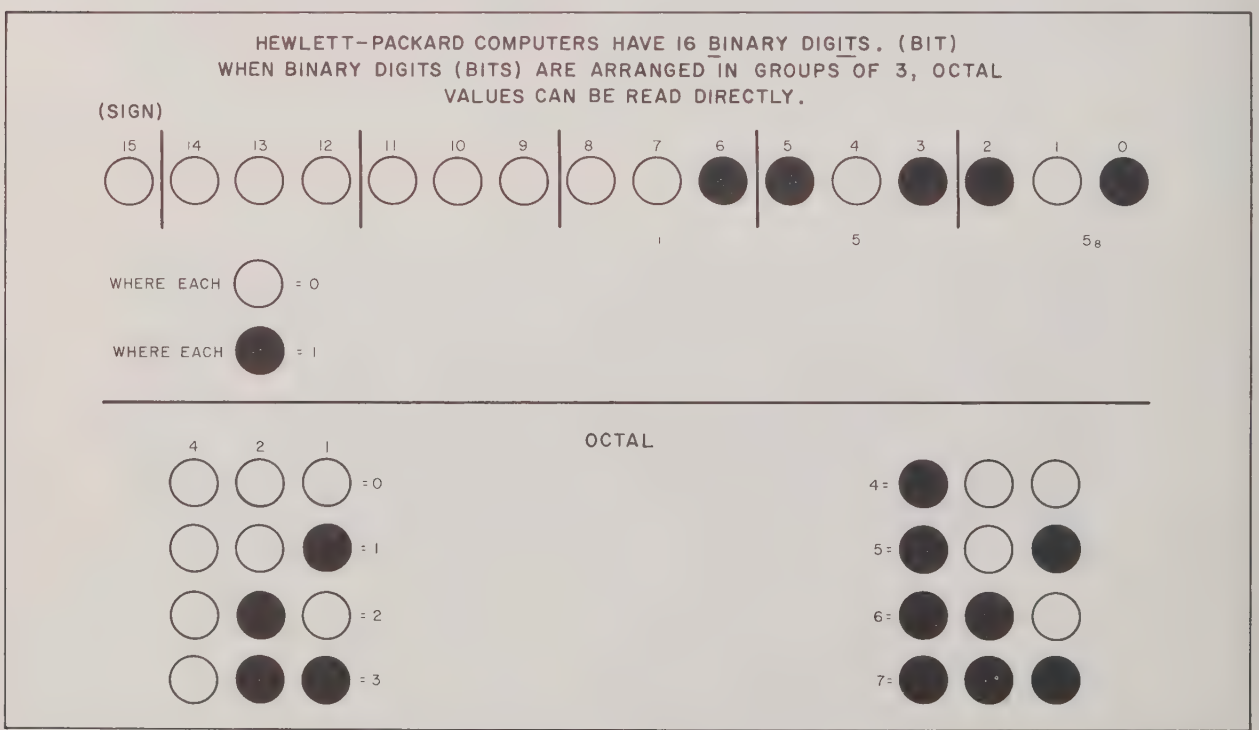
3-31. POWER. Regulated power to each of the HP computers automatically goes off in case of abnormal changes in internal power supplied. If the computer is halted, contents of memory are not affected by switching power off and on. Contents of working registers, however, are lost when power goes off (contents are random following turn-on). The 2116B POWER switch lights when power is on. The 2114A and 2115A Computers have toggle POWER switches located on the right side of the 2115A front panel, and behind the front panel, on the computer chassis, of the 2114A (accessible only by using a key).

3-32. LOADER (2115A and 2116B)/LOAD (2114A). These switches are associated with the last 64 locations of memory; for example octal addresses 07700 through 07777 in 4K computers, or 17700 through 17777 in 8K computers. These locations are normally occuppied by the Basic Binary Loader.

a. When the LOADER switch of the 2115A, 2116B is set to ENABLED the last 64 locations of memory can be read or loaded; in the PROTECTED position, these locations are disabled.

b. The LOAD switch of the 2114A is interlocked electrically with the PRESET switch. To load a program these switches must be touched simultaneously.

Figure 3-4. Binary/Octal Relationship of Computer SWITCH REGISTER



3-33. PRESET. This switch presets the computer to the "Fetch" phase, to turn off the interrupt system and all input/output control bits, and to set all input/output Flag bits. This switch resets the PARITY HALT indicator on the front panel of the 2116B and 2115A Computers, and the PARITY indicator on the front of the 2114A. It also clears the power fail interrupt circuits. An internal preset pulse accomplishing the same functions is generated each time power is switched on or off.

3-34. RUN. This switch starts operation at the current state of the computer. This switch lights when a program is running, and goes off when HALT button is pressed, when a HLT instruction is executed, or when an abnormal change occurs in internal power supplies. When the RUN light is on, all front panel control switches except HALT, POWER and LOADER (2116B, 2115A) are disabled, as well as the CLEAR REGISTER switch on the 2114A.

3-35. HALT. This switch stops computer operation at the end of the current phase. When the computer is halted, the HALT switch lights, and all front panel control switches are enabled (on the 2114A, the P register will not increment if the HALT and LOAD memory or HALT and DISPLAY MEMORY switches are touched simultaneously).

3-36. LOAD MEMORY. This switch stores the contents of the SWITCH REGISTER in the memory location specified by the address in the M (MEMORY ADDRESS or 2114A) register. The P and M registers are automatically incremented after operation of the LOAD MEMORY switch to simplify storing data into consecutive memory locations (exception for 2114A: see HALT switch description). The stored data remains displayed in the T register (MEMORY DATA register on 2114A), and the Fetch phase is set at the end of the load operation.

3-37. LOAD A (2115A/2116B only). This switch transfers the contents of the SWITCH REGISTER into the A register. The computer's phase status is not altered.

3-38. LOAD B (2115A/2116B only). This switch transfers the contents of the SWITCH REGISTER into the B register. The computer's phase status is not altered.

3-39. LOAD ADDRESS. This switch transfers the contents of the SWITCH REGISTER into the P and M (MEMORY ADDRESS on 2114A) registers, thus, directing the computer to the desired address. The Fetch phase is set at the end of the load operation.

3-40. DISPLAY MEMORY. This switch causes the contents of the address specified in the M register to be displayed in the T (MEMORY DATA on 2114A) register. The P and M registers are automatically incremented after operation of the DISPLAY MEMORY switch, so that consecutive memory locations may be displayed by repeated operation of this switch. The P and M registers are therefore one step ahead of the T register's display. The Fetch phase is set after incrementing the P and M registers (exception for 2114A: see HALT switch description).

3-41. SINGLE CYCLE. This switch executes one machine phase each time it is pressed.

3-42. CLEAR REGISTER (2114A only). This switch resets the SWITCH REGISTER to all "zeros" (switch lights out).

3-43. LOADER ENABLE-ON/NORMAL (2114A only). This switch is located on the inside of the front panel; see Figure 3-5. The NORMAL position protects the contents of the last 64 locations in memory normally occuppied by the Basic Binary Loader. In the ON position, the Loader is enabled to allow words in the Loader area to be changed, or a new loader program to be entered.

3-44. LAMP TEST-TEST/NORMAL (2114A only). This switch is located on the inside of the front panel, see Figure 3-5, and permits testing of all indicator lights on the front panel.

3-45. CONSOLE LOCK-LOCK/NORMAL (2114A only). This switch is located on the inside of the front panel, see Figure 3-5. In the LOCK position, the front panel switches are disabled to permit continuous computer operation without accidental interruption or tampering. Wire jumpers on the switch printed circuit card can be removed to permit the SWITCH REGISTER switches or the bottom row of control switches to be disabled individually, if desired. With the switch in the NORMAL position, all front panel switches are enabled.

3-46. 5480A Memory/Display Unit

(See Figure 3-6)

3-47. INTENSITY: Adjusts CRT trace intensity. Prevent CRT phosphor burns by keeping intensity as low as possible while maintaining good trace visibility.

3-48. TRACE ALIGN: Rotates trace for alignment with horizontal axis of graticule.

3-49. FOCUS: Adjusts CRT focus. Set for smallest spot size.

3-50. CALIBRATOR: 1 volt peak to peak square wave. Output frequency depends on sweep time to maintain the same number of cycles on CRT display regardless of sweep time.

3-51. HORIZONTAL POSITION: Moves trace horizontally on CRT.

3-52. MAGNIFIER: Expands horizontal display scale by factor of 5 to provide increased resolution.

3-53. ON Lamp: Lights when ac power is applied.

3-54. RESET Lamp: Lights to indicate that ac power has been interrupted. Memory contents are protected against ac interruption but processing cannot continue until the interruption has been acknowledged by resetting. Reset by turning POWER off for about 1 second.

3-55. POWER: Switch controls ac power to 5480A.

Figure 3-5. 2114A Front Panel (Rear View)

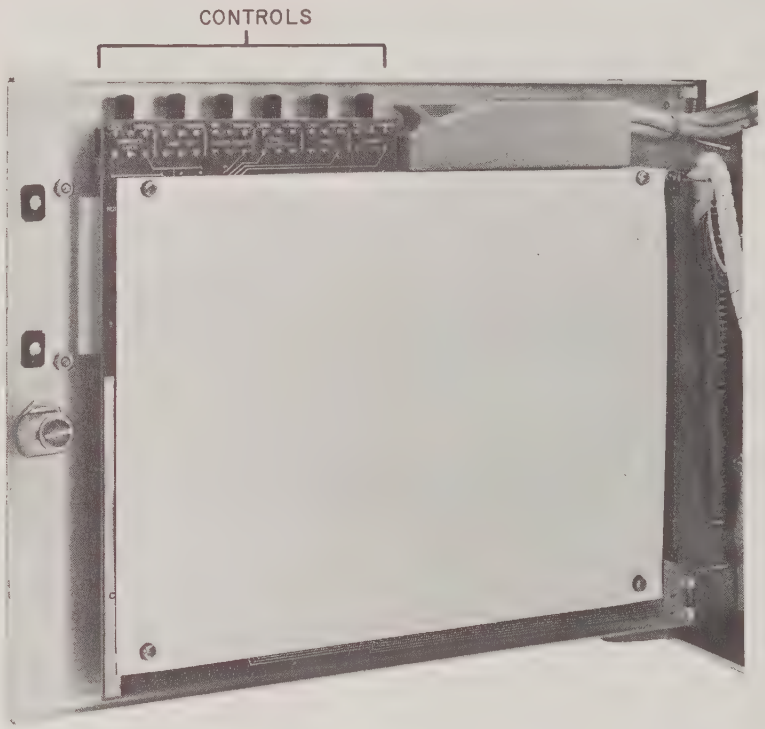
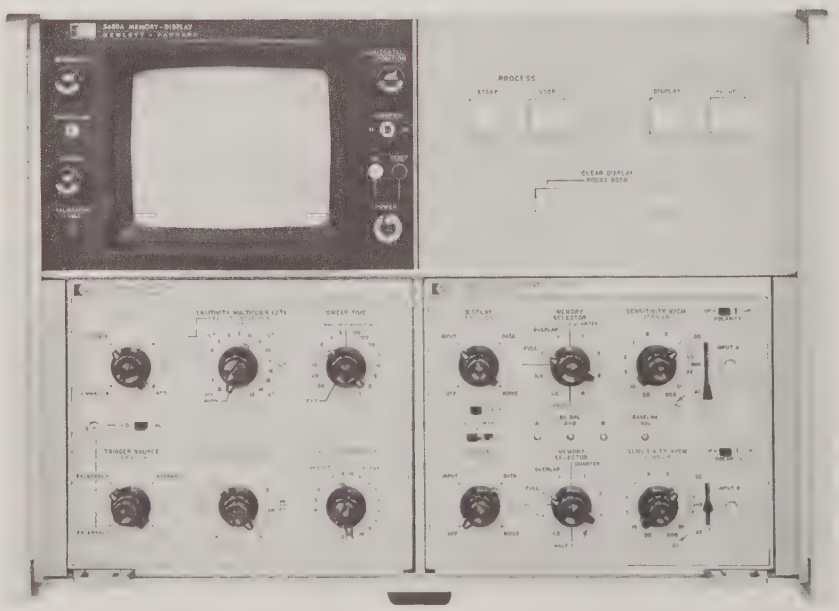


Figure 3-6. 5480A Front Panel



3-56. PROCESS and OUTPUT: Controls are push-button switches containing indicator lamps. Lighted button indicates memory activity in progress.

3-57. PROCESS-START: Enables signal processing by memory. Processing begins at first sync pulse after button is pressed. If pressed while STOP or DISPLAY button is lighted, processing resumes at next sync pulse. Button remains lighted during signal processing.

3-58. PROCESS-STOP: Stops signal processing. No CRT display.

3-59. OUTPUT-DISPLAY: Causes memory contents to be displayed on CRT. Stops signal processing (after current sweep is completed) if pressed while START button is lighted.

3-60. OUTPUT RECORD: When signal processing is stopped, causes 5480A to step through memory contents once at rate selected by SWEEP TIME control. Memory contents are provided in analog form at rear panel output connectors. Output signal can be recorded by X-Y recorder at rate which recorder pen can follow (a pen lift signal is also provided at rear panel).

3-61. CLEAR DISPLAY: Both pushbutton switches must be pressed simultaneously to erase memory contents being displayed on CRT. The use of two buttons prevents accidental erasure of memory.

3-62. REAR PANEL. (See Figure 3-7)

Note

The following are controls and connectors pertinent to the 5481A System.

3-63. SCALE CAL: Provides means for calibrating an X-Y recorder connected at OUTPUT connectors. When 5485A plug-in DISPLAY control is set to DATA, SCALE CAL operates as follows:

a. In DUAL, a dot appears at upper right corner of CRT.

b. In ZERO, a dot appears at lower left corner of CRT.

c. In OFF, 5480A operates normally.

d. HORIZ DAC: Provides 0V to +10V ramp proportional to each memory address.

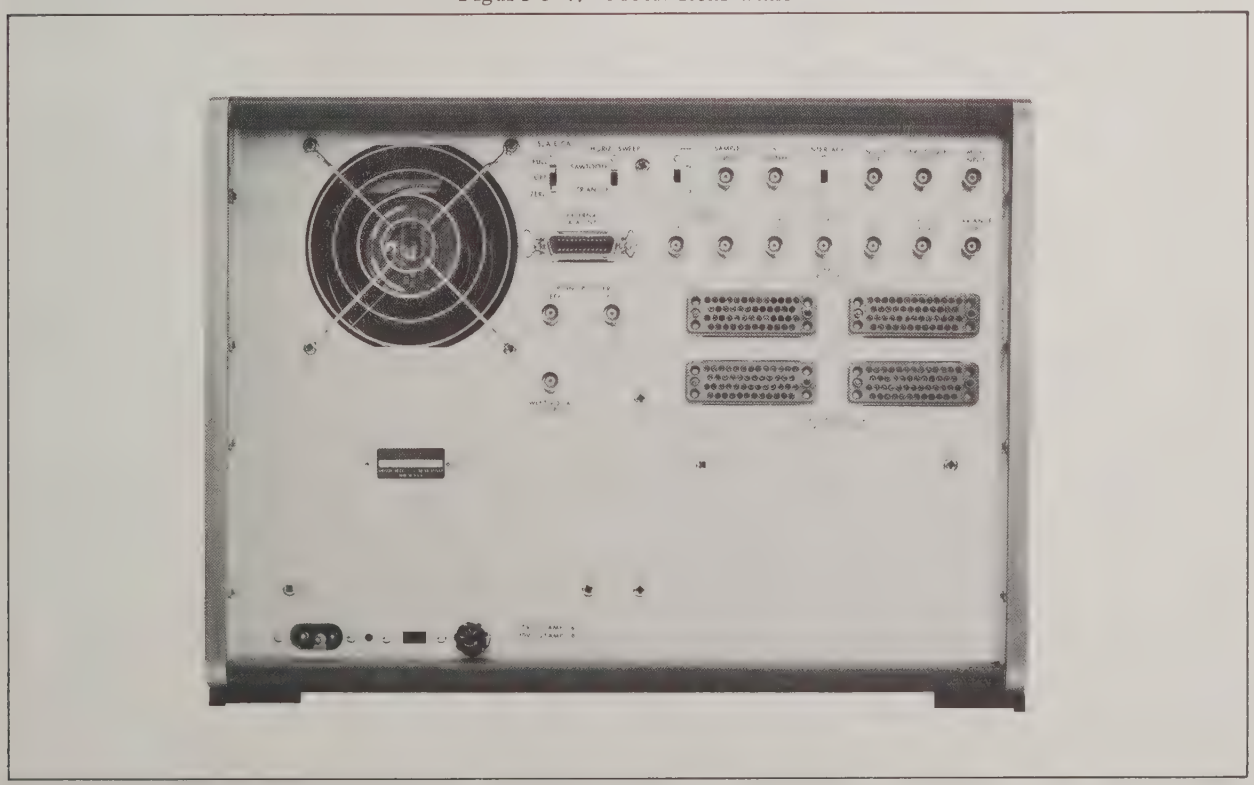
e. VERT DAC: Provides -5V to +5V, proportional to vertical display.

f. Z AXIS: Provides +5V pulse for oscilloscope blanking.

g. PEN LIFT CONTROL: Provides signal to drop X-Y recorder pen at start of sweep and lift pen at end of sweep.

h. POINT PLOTTER-SEEK: Supplies signal, telling point plotter to plot a point.

Figure 3-7. 5480A Rear Panel



i. POINT PLOTTER-PLOT: Receives signal from plotter indicating point has been plotted.

j. CONNECTOR B: Connects to Control interface card in computer.

k. CONNECTOR C2: Connects to Data Buffer interface card in computer.

Note

Instructions for interconnection of 5480A to computer are located in Section II.

3-64. 5486A Control Plug-in

(See Figure 3-6)

3-65. FUNCTION-AVERAGE: Keeps "calibrated average" of successive input signal repetitions. Provides continuous calibrated display (Paragraph 3-148).

3-66. SENSITIVITY MULTIPLIER (2^N): Multiplies vertical display size by 2^N. Dial is calibrated in N (see Table 3-1), thus, as control is turned clockwise each position doubles display size. In AUTO, vertical display is controlled by SENSITIVITY V/CM switch on 5485A Input plug-in unit.

3-67. SWEEP TIME: Determines rate at which the process address register steps through memory (processing rate). In EXT, a signal connected to SAMPLE INPUT connector (on rear panel of 5480A Memory/Display Unit) is converted to a train of sampling pulses; nearly any periodic waveform may be used for this application.

3-68. Input Connector: Sync input for AVERAGE mode; see Paragraph 3-148.

3-69. AC/DC: Selects ac coupling or dc coupling of input sync signals in AVERAGE mode.

3-70. TRIGGER SOURCE/-LEVEL+: TRIGGER SOURCE selects triggering level signal from: INTERNAL, uses sync signal generated at end of each sweep (5480A is free running); LINE, uses signal derived from power line frequency; EXTERNAL + or -, uses signal at Input Connector, derives sync pulse from positive or negative signal slope.

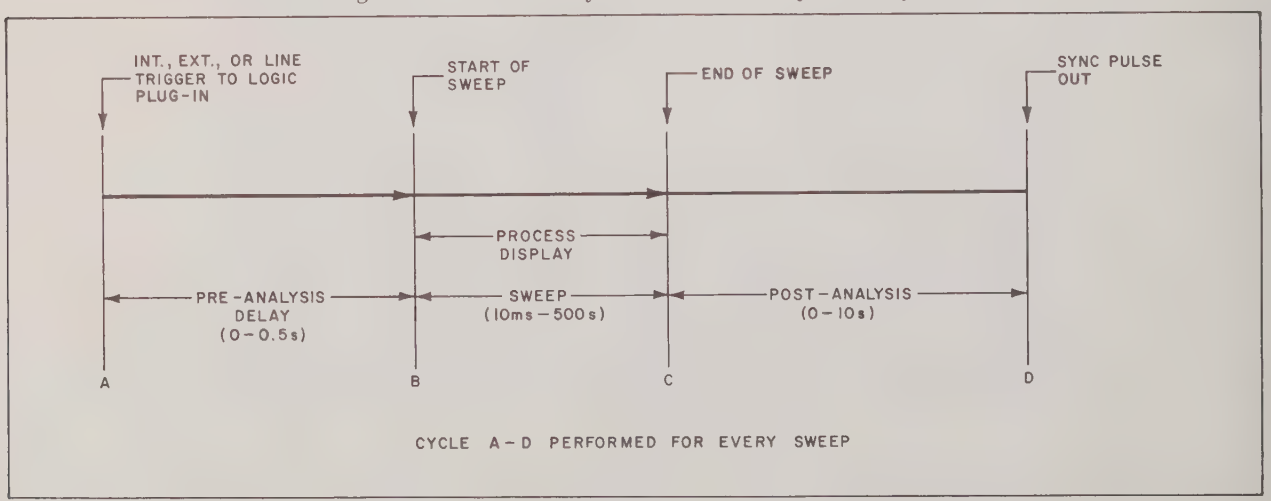
3-71. PRE-ANALYSIS DELAY: Provides calibrated 20 μs to .5 second delay between input sync signal and start of sweep. Conserves memory and increases resolution by eliminating unnecessary front portion of data waveform display (see Figure 3-8).

3-72. POST-ANALYSIS DELAY: Provides uncalibrated zero to 10 second delay of output sync pulse occuring at end of every sweep. If this sync output is used to start each repetition of an experiment, start of experiment will be delayed by this amount (see Figure 3-8).

Table 3-1. N to 2^N Conversion

N	2^N
0	1
1	2
2	4
3	8
4	16
5	32
6	64
7	128
8	256
9	512
10	1024
11	2048
12	4096
13	8192
14	16384
15	32768
16	65536
17	131072
18	262144
19	524288

Figure 3-8. Pre-Analysis and Post-Analysis Delays



3-73. SWEEP NUMBER (2^N): Selects number of sweeps or repetitions to be averaged. Dial is calibrated in N (see Table 3-1), number of sweeps is 2^N (for example, SWEEP NUMBER 3 causes 8 sweeps to be averaged). Signal-to-noise ratio improvement in dB is approximately 3N. For example, where N is 3, dB improvement is 9 dB.

3-74. SWEEP NUMBER (2^N) - PRESET (Average): 5480A averages number of sweeps selected by SWEEP NUMBER, stops and displays results. See Paragraph 3-148. This is stable averaging.

Note

In PRESET (Average), if SWEEP NUMBER is set to 19, 5480A will stop and display result after 2^{18} sweeps.

3-75. SWEEP NUMBER (2^N) - NORMAL (Average): 5480A averages number of sweeps selected by SWEEP NUMBER, and continues averaging with this number of sweeps defining the weighting time constant until stopped manually. This is weighted averaging, see Paragraph 3-148.

3-76. 5485A Two Channel Input Plug-in
(See Figure 3-6)

3-77. DISPLAY: Selects CRT display for its channel. INPUT displays raw, unprocessed input signal. DATA displays averaged signal. NOISE displays difference between INPUT and averaged signal. OFF turns channel off.

3-78. POSITION: Adjusts vertical position of its channel on CRT display.

3-79. MEMORY SELECTOR: Selects portion of memory to be used for storage, display or processing. Memory is divided into 4 quarters. Operator may select memory portions for either channel as follows:

QUARTER 1
QUARTER 2
QUARTER 3
QUARTER 4
HALF (QUARTERS 1 and 2)
HALF (QUARTERS 3 and 4)
FULL (QUARTERS 1, 2, 3, and 4)

3-80. MEMORY SELECTOR-OVERLAP: All four quarter sections are displayed simultaneously as separate traces. When MEMORY SELECTOR controls are set to cause both channels to be connected to the same memory quarter, Channel A takes precedance. For example, if MEMORY SELECTOR A is set to FULL, no quarter is left for B; if MEMORY SELECTOR A is set to QUARTER 1, and MEMORY SELECTOR B is set to FULL, Channel A uses QUARTER 1 and Channel B uses QUARTERS 2, 3, and 4.

3-81. SENSITIVITY V/CM: Attenuates input signal and provides calibration of vertical display from 5 mV/cm to 20 V/cm.

3-82. VERNIER: Provides continuous uncalibrated attenuation of vertical display. Does not affect input signal amplitude stored in memory.

3-83. DC/GND/AC: Switches from dc coupling, grounding, or ac coupling of input. In GND, INPUT connector is open circuited, and input to amplifier is grounded to provide a zero reference.

3-84. POLARITY: Inverts input signal, allowing waveform to be displayed with positive voltage above baseline (UP+) or below baseline (-UP).

3-85. INPUT A/B: Input for AVERAGE function.

3-86. ALT/A+B: In ALT, Channels A and B operate separately. In A+B, signal at INPUT B is added to signal at INPUT A and sum is fed through Channel A only. Difference between two signals can be averaged by setting one channel to UP+ and the other to -UP.

3-87. DC BAL controls: Compensate for small dc offsets in the input circuits so dc input will be stored as "0" in memory. Refer to Section IV of 5480A Operating Manual for calibration procedures.

3-88. BASELINE ADJ: Adjusts baseline to prevent baseline drift during summation.

3-89. OPERATING COMMANDS FOR 5481A SYSTEM

3-90. The 5481A System is shipped with a configured system tape which permits immediate operation of the system. Refer to 5481A Software Manual for information on other system software. The tape for systems with 4K memory contains subroutines that compute Fourier transform, inverse Fourier transform, and display of Fourier components, i.e. real, imaginary, magnitude, phase, and power. The tape for systems with 8K or more of memory contain additional subroutines that compute auto and cross correlation, integration, differentiation, inputting and outputting of data, and addition, subtraction and transfer of data between 5480A memory segments.

3-91. Table 3-2 lists all callable routines of the system tape. The computer SWITCH REGISTER is used to call these subroutines (SWITCH REGISTER is discussed in Paragraphs 3-29 through 3-30). Subroutines have been divided into 3 groups; see Table 3-2. Common to all groups are columns A and B (switches 3, 2, 1 and 0). The settings of these switches permit selection of the 5480A memory segment to be processed by the computer. Table 3-3 shows how switch settings correspond to the various 5480A memory segments. Column A represents memory division i.e. FULL, HALF, or QUARTER. Column B represents the segment number for that particular memory division. Table 3-3 also shows the correspondence between the MEMORY SELECTOR switch of the 5485A Plug-in (part of 5480A Signal Analyzer) and the settings of switches 3, 2, 1 and 0 of the SWITCH REGISTER. When using the display subroutine, set the MEMORY SELECTOR switch on the 5480A to correspond to the memory segment selected by the computer SWITCH REGISTER.

Table 3-2. SWITCH REGISTER Settings for System Tape Routines

Routine	SWITCH REGISTER Setting															
	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
													B		A	
FOURIER TRANSFORM	0	0	0	0	1											
INVERSE FOURIER TRANSFORM	0	0	0	0	0	1										
DISPLAY FOURIER COMPONENT:																
REAL	0	0	0	0	0	0	1					1				
IMAGINARY	0	0	0	0	0	0	1				1	0				
MAGNITUDE	0	0	0	0	0	0	1			1	0	0				
PHASE	0	0	0	0	0	0	1		1	0	0	0				
POWER	0	0	0	0	0	0	1	1	0	0	0	0				
The following routines apply only to systems with 8K memory																
AUTO CORRELATION	0	0	0	1												
REMOVE DC COMPONENT	0	0	1	1												
INTEGRATE	0	0	1	0	1							D				
DIFFERENTIATE	0	0	1	0	0	1						D				
SCALE	0	0	1	0	0	0	1				F	D				
INPUT	0	0	1	0	0	0	0	1			E	D				
OUTPUT	0	0	1	0	0	0	0	0	1		E	D				
CROSS CORRELATION (illegal in FULL memory)	0	1	0	1						G	C	C				
ADD B + C → C	0	1	0	0	1					G	C	C				
SUB B - C → C	0	1	0	0	0	1				G	C	C				
TRANSFER B → C	0	1	0	0	0	0	1				C	C				

1

2

3

These switch settings may be 1 or 0.

A, B: Settings of these switches select 5480A memory segment to be processed. See text.

C: Select second 5480A memory segment, when two are needed.

D: Set to 1, if more data is to be entered.

E: Set to Ø when Teletype is used (for both INPUT and OUTPUT); set to 1, for Photoreader (INPUT) or Tape punch (OUTPUT) is used.

F: Set to Ø, to scale down; set to 1, to scale up.

G: When set to Ø, data is stored in 5480A memory segment designated by switches 5, 4. When set to 1, data is stored in 5480A memory segment designated by switches 3, 2, 1, and Ø.

3-92. For some operations, more than one 5480A memory segment must be specified. For example, when adding 2 memory segments together both segments to be operated on must be specified. All operations in group 3 (see Table 3-2) use columns A, B, and C for memory selection (switches 5, 4, 3, 2, 1, and 0 of the SWITCH REGISTER). Column A specifies memory division. Columns B and C specify which two 5480A memory segments are used, see Table 3-4. The two specified memory segments must be of the same length, i.e. a QUARTER memory segment and a HALF memory segment cannot be added.

3-93. Table 3-4 also shows legitimate combinations for selection of two 5480A memory segments. Column A determines FULL, HALF, or QUARTER memory operation. In FULL memory there is only one memory segment. Performing an addition operation would amount to multiplying the data contained in the FULL memory segment by 2. In HALF and QUARTER memory one of the combinations from Column B and one from C may be selected. Operations such as outputting of data may require more information. For example, to output 50 points of a 1000 point waveform with starting address 500, two additional data words are needed; see Table 3-5. This data word is sent to the computer in BCD form, i.e. each decimal digit to be inputted to the computer is divided into 4 bits. Thus, the decimal digits 0-9 are represented by BCD codes shown in Table 3-5. Examples show how decimal information can be set into the SWITCH REGISTER to communicate with the computer. In this way the starting address and the number of words to be processed can be specified. Areas D through G in Table 3-2 will be explained under the description of the individual operations.

Table 3-3. Memory Selection for One Segment

Computer SWITCH REGISTER				5480A Memory Segment
3	2	1	0	
X	X	0	0	FULL
X	0	0	1	HALF 1, 2
X	1	0	1	HALF 3, 4
0	0	1	X	QUARTER 1
0	1	1	X	QUARTER 2
1	0	1	X	QUARTER 3
1	1	1	X	QUARTER 4

B — Memory Segment
A — Memory Division

Table 3-4. Memory Selection for Two Segments

Computer SWITCH REGISTER						5480A Memory Segment
5	4	3	2	1	0	
X	X	X	X	0	0	FULL
X	0	X	0	0	1	HALF
X	1	X	1			
0	0	0	0	1	X	QUARTER
0	1	0	1			
1	0	1	0			
1	1	1	1			

C — Segment 2
B — Segment 1
A — Memory Division

Table 3-5. BCD Coding of SWITCH REGISTER

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
D4				D3				D2				D1			

D1 through D4 represent decimal digits as follows:

Ø = 0000
1 = 0001
2 = 0010
3 = 0011
4 = 0100
5 = 0101
6 = 0110
7 = 0111
8 = 1000
9 = 1001

Examples:

Decimal	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
2793	0	0	1	0	0	1	1	1	1	0	0	1	0	0	1	1
48	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0
500	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0

3-94. FOURIER TRANSFORM

3-95. This routine takes a real time waveform stored in the 5480A memory and transforms it from the time domain into the frequency domain to obtain a frequency spectra. In a like manner, once in the frequency domain the inverse Fourier transform routine may be used to go back to the time domain.

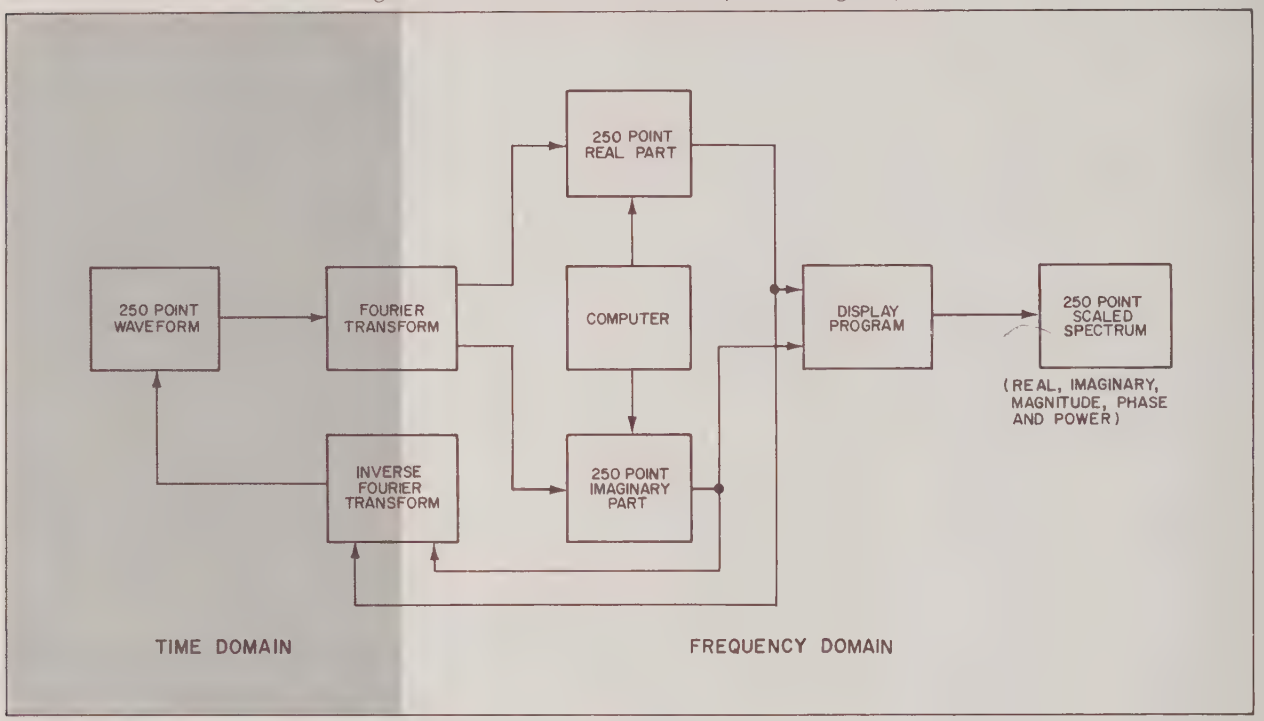
3-96. Figure 3-9 shows a detailed representation of how the Fourier transform has been implemented into the 5481A System. First, a 250, 500, or 1000 point real time waveform is gathered in the 5480A Signal Analyzer. This information is then transferred to the computer where the computer performs a Fourier transform on the data. The result is a 250, 500, or 1000 point real part, plus a 250, 500, or 1000 point imaginary part stored in the computer. The real and imaginary frequency components represents a transform pair which completely characterizes the original waveform.

3-97. The real and imaginary frequency components are always stored in the computer in normalized form, i.e., the block of data containing 16-bit words is stored in such a way that it contains as much significant information as possible. To do this, both the real and imaginary parts have been scaled accordingly.

3-98. To see the frequency spectra, a display program has been incorporated into the system. This display program allows the user to display the real, imaginary magnitude and phase or power spectra on the CRT of the 5480A Memory/Display unit. This program removes the normalizing factor from the data so a calibrated waveform is displayed on the CRT. In the case of the magnitude, phase, and power spectra, each point is computed from the real and imaginary parts and then displayed. In this way the real and imaginary frequency components are the only components that are stored in the computer.

3-99. Figure 3-10 shows the magnitude spectrum of a pulse (the (sin x)/x distribution). In interpreting the magnitude spectra displayed on the 5480A Memory/Display unit CRT, the horizontal axis represents frequency and the vertical axis represents amplitude. On the horizontal axis dc is in the center, plus frequency

Figure 3-9. Fourier Transform (Block Diagram)



going to the right and minus frequency going to the left. The calibration of the frequency spectra is dependent on the setting of the SWEEP TIME switch on the 5486A Control Plug-in (part of the 5480A Signal Analyzer) and the 5480A memory segment used. Using Table 3-6 actual calibration can be determined when these variables are known. For example, with a sweep time of 10 msec/cm in the time domain, the frequency domain calibration would be 10 Hz per point. If a QUARTER memory segment is chosen there are 25 points per cm. This gives a frequency calibration of 250 Hz/cm. The total frequency range would be ±1250 Hz. In the same way, HALF memory segments provide a calibration of 500 Hz/cm or ±2500 Hz full range. With FULL memory, calibration is 1000 Hz/cm and a full range capability of ±5000 Hz.

Note

In general the real and imaginary parts are not useful for interpretation. The magnitude, phase, and power spectra should be used for most interpretation.

3-100. When phase information is displayed, the frequency calibration remains the same as discussed above, but the vertical axis is calibrated to give a display of 45 degrees per centimeter. Thus, with zero in the center of the screen, full scale display (±4 cm) would be ±180 degrees.

3-101. USING SYSTEM TAPE ROUTINES

3-102. Routines are executed by setting SWITCH REGISTER according to Table 3-2 and pressing RUN button on the computer.

3-103. Fourier Transform

3-104. This routine computes the Fourier transform of a waveform stored in a memory segment of the 5480A Signal Analyzer specified by the computer SWITCH REGISTER, see Table 3-3. The result of the Fourier transform, i.e. the real and the imaginary frequency spectra will then be stored in the computer. No change will occur to the data stored in any 5480A memory segment.

3-105. Inverse Fourier Transform

3-106. This routine computes the inverse fourier transform on the real and the imaginary frequency

Figure 3-10. Magnitude Spectrum (Sin X)/X

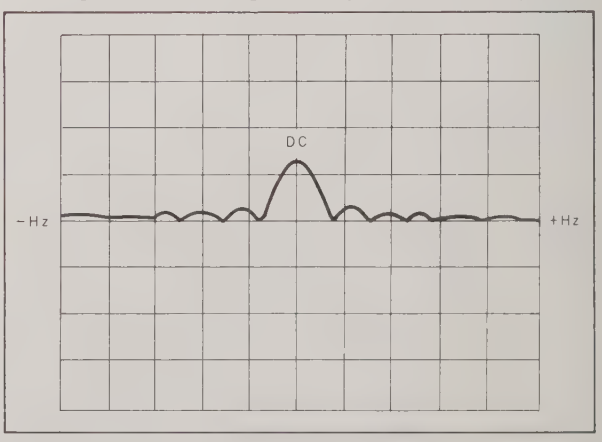


Table 3-6. CRT Calibration

TIME DOMAIN	FREQUENCY DOMAIN						
sweep time sec/cm	Hz/point	Quarter Memory		Half Memory		Full Memory	
		Hz/cm	full range	Hz/cm	full range	Hz/cm	full range
.001	100	2500	12500	5000	25000	10000	50000
.002	50	1250	6250	2500	12500	5000	25000
.005	20	500	2500	1000	5000	2000	10000
.01	10	250	1250	500	2500	1000	5000
.02	5	125	625	250	1250	500	2500
.05	2	50	250	100	500	200	1000
.1	1	25	125	50	250	100	500
.2	.5	12.5	62.5	25	125	50	250
.5	.2	5	25	10	50	20	100
1	.1	2.5	12.5	5	25	10	50
2	.05	1.25	6.25	2.5	12.5	5	20
5	.02	.5	2.5	1.0	5	2	10
10	.01	.25	1.25	.5	2.5	1.0	5
20	.005	.125	.625	.25	1.25	.5	2.5
50	.002	.05	.25	.1	.5	.2	1.0

spectra stored in the computer. The result (the real time waveform) will be stored in the 5480A memory segment specified by switches 0-3 of the SWITCH REGISTER.

Note

An error message may be typed on the Teleprinter if the lengths of the real and imaginary parts stored in the computer do not agree with the specified memory segment, or if the real and imaginary parts are not defined within the computer. Error messages are not typed on the Teleprinter of systems with 4K memory.

3-107. Display Fourier Component

3-108. This routine displays the real, imaginary, magnitude, phase, or power spectra as specified by switches 4-8 of the computer SWITCH REGISTER, see Table 3-2. The frequency component chosen will be transferred into the selected 5480A memory segment specified by the SWITCH REGISTER; see Note after Paragraph 3-106.

3-109. The following routines apply only to systems with 8K or more memory.

3-110. Auto-Correlation

3-111. This routine computes the auto-correlation of a waveform stored in the memory segment specified by the computer SWITCH REGISTER (switches 0, 1, 2, and 3). The auto-correlation function will replace the original waveform.

Note

Original data may be stored on paper tape or in another 5480A memory segment (HALF or QUARTER memory only) before computing the auto-correlation (see Paragraph 3-123).

3-112. Remove DC Component

3-113. This routine removes any dc component from a real time waveform. The routine will operate on the waveform stored in the specified memory segment of the 5480A. This routine is very useful when used with the Integration routine. The integration of a constant dc level will result in a ramp. If the dc level is very large this ramp will eventually produce a data overflow.

3-114. Integration

3-115. This routine will integrate data in a 5480A memory segment specified by the SWITCH REGISTER. It is not a straight summation routine but the result is scaled so it gives calibration in square centimeters. For example, if one of the memory segments contained a dc level of 1 cm, the integration of that level will be a ramp rising at 1 cm/cm. If a dc level is superimposed on the signal it may (depending on the dc level and the waveshape) cause data overflow. Overflow may be verified by outputting data on the Teleprinter; if ±8388607 is typed, data overflow has occurred. Overflow can be prevented by scaling the data (with the scaling routine) or by removing the dc component (with the remove dc component routine).

3-116. If switch 4 (computer SWITCH REGISTER) is set to zero, integration will be performed over the entire waveform. To perform the integration over a selected portion of the waveform, switch 4 is set to one. This allows selection of the starting address (where the integration is to begin) and the number of points to be integrated. First, the SWITCH REGISTER is set according to Table 3-2 to perform the integration routine. Set switch 4 (D) to one. Switches specified in Column A and B of Table 3-2 are set according to the desired memory segment. Next, push computer RUN button. The computer will HALT with 102051_8 in

the T (MEMORY DATA on 2114A) register. Set SWITCH REGISTER to the BCD code of the starting address where integration is to begin (see Table 3-5) and push computer RUN button. Computer will HALT with 102052_8 in the T (MEMORY DATA on 2114A) register. Now set SWITCH REGISTER to the BCD code representing the selected number of points to be integrated, (see Table 3-5) and press RUN. Integration routine is now executed.

3-117. Differentiate

3-118. This routine computes the derivative of a waveform stored in the 5480A Signal Analyzer. The scaling for this routine is set up so that any waveform that has been integrated (with the integration routine) can be differentiated to get the original waveform back. Waveforms containing very fast risetime, e.g. square waves, may cause an overflow to occur when differentiated. Scaling the waveform down (refer to Paragraph 3-120) may help to prevent overflow from occuring on such waveforms.

Note

Differentiating is very sensitive to waveforms that have noise in them. Differentiating a noisy waveform will cause scattering on the resulting waveform.

3-119. In the same way as integration it may be desired to differentiate a selected portion of a waveform. This is done by selecting the starting address of the waveform and the number of points to be differentiated. Refer to Paragraph 3-116.

3-120. Scale

3-121. This routine permits scaling of 5480A memory data up or down. This scaling operation may cause overflow or underflow to occur depending on the value of data and the magnitude of the scale factor chosen. Data is scaled down by setting switch 5 (F) of the SWITCH REGISTER to zero, see Table 3-2. With switch 5 set to one, data will be scaled up.

3-122. To scale data, first set SWITCH REGISTER for scaling routine, see Table 3-2. Next push computer RUN button. The computer will HALT 102051_8 in the T (MEMORY DATA on 2114A) register. Now set the BCD value of the scaling factor into the SWITCH REGISTER, see Table 3-5. Push computer RUN button. Routine will execute scaling factor chosen by the SWITCH REGISTER.

3-123. Output

3-124. This routine outputs digital data stored in the 5480A to the Teleprinter or the paper tape punch. With switch 5 (E) of the SWITCH REGISTER set to zero, the Teleprinter is the output device, see Table 3-2. With switch 5 set to one, the paper tape punch is the output device. If there is no paper tape punch in the system the Teleprinter will be the output device regardless of switch setting.

3-125. An example of the output provided by this routine is shown in Table 3-7. Each number is seven decimal digits. For positive numbers the + sign is not printed. Each number has an implied decimal point after the first digit, thus, the first number for example is -1.073153 centimeters (below baseline). Note (especially in averaging) there may be no more than 3 to 5 digits of actual significance. Direct calibration of output is obtained by associating output information (in cm) with Input Attenuator setting of 5480A Input Plug-in (e.g. 5485A SENSITIVITY V/CM switch). Data is outputted in lines of 5 data words per line and divided into groups of 2 and 10 lines. This gives an overall formatting of 5, 10 and 50 word blocks of data. The beginning of a block of data is signified by the # sign. The end of a block of data is signified by a $ sign. These two characters designate the beginning and end of records when used with paper tape.

3-126. Outputting of smaller blocks of data is performed the same way as described in Paragraph 3-116, i.e., set SWITCH REGISTER to call Output routine, then select starting address and size of data block to be outputted.

Table 3-7. Example of Output Format

```
#
-1Ø73153  -1Ø24ØØ1  -Ø999425  -Ø966657  -Ø942Ø81
-Ø9Ø9313  -Ø884737  -Ø868353  -Ø835585  -Ø671745

-Ø647169  -Ø6144Ø1  -Ø598Ø17  -Ø565249  -Ø548865
-Ø516Ø97   Ø417792   Ø344Ø64   Ø3Ø31Ø4   Ø155648

 Ø12288Ø   Ø1Ø6496   ØØ73728   ØØ4Ø96Ø   ØØ16384
 ØØØ8192  -ØØØ8193  -ØØ32769  -ØØ65537  -ØØ73729

-ØØ983Ø5  -ØØ983Ø5  -1Ø73153  -1Ø4Ø385  -1ØØ7617
-Ø983Ø41  -Ø95Ø273  -Ø9Ø1121  -Ø884737  -Ø729Ø89

-Ø696321  -Ø663553  -Ø638977  -Ø6144Ø1  -Ø589825
-Ø573441  -Ø557Ø57  -Ø54Ø673  -Ø4Ø96ØØ  -Ø344Ø64


 Ø278528   Ø16384Ø   Ø131Ø72   ØØ9Ø112   ØØ73728
 ØØ49152   ØØ16384   ØØØØØØØ  -ØØØ8193  -ØØ32769

-ØØ65537  -ØØ65537  -ØØ9Ø113  -ØØ983Ø5  -1Ø73153
-1Ø48577  -Ø999425  -Ø958465  -Ø925697  -Ø9Ø9313

-Ø77ØØ49  -Ø737281  -Ø7Ø4513  -Ø671745  -Ø647169
$
```

3-127. Input

3-128. This routine inputs data to the 5480A Signal Analyzer from the Teleprinter or Photoreader. When switch 5 (E) of the SWITCH REGISTER is set to zero, the Teleprinter is the input device, see Table 3-2. With switch 5 set to one, the photoreader is the input device. If there is no photoreader in the system the Teleprinter is the input device regardless of the switch setting.

3-129. The input and output data formats are the same. Thus, a paper tape that has been punched using the Output routine can be inputted using the Input routine. In addition, several less restrictive formats can be used for inputting, starting with the format shown in Table 3-7. For inputting, the following features have been incorporated into the Input routine.

a. The additional line feed used for blocking off data in the output format while inputting may be suppressed.

b. Less than 5 data words per line may be typed.

c. Any data word may be terminated short of its assigned seven digits by pressing the RETURN and LINE FEED keys on the Teleprinter.

3-130. When entering data via the Teleprinter, the # sign must be typed first, followed by RETURN and LINE FEED to start inputting a block of data. When this is done input data may then be inputted to the 5480A from the Teleprinter. The input record can be terminated at any point independent of the length of the block originally chosen by typing the $ sign. The $ sign acts as an absolute terminator to the block of data being inputted.

3-131. A starting address and the number of data words may be selected by setting switch 4 (D) of the SWITCH REGISTER to one, see Table 3-2. Refer to Paragraph 3-116.

3-132. Cross Correlation

3-133. This routine computes the cross-correlation function between two 5480A memory segments. Switches 5, 4, 3, 2, 1 and 0 (of the SWITCH REGISTER) are used to select the two memory segments to be cross correlated, see Table 3-4. The resulting cross correlation waveform is stored in the 5480A memory segment selected by switches 5 and 4.

3-134. With switch 6 set to one, the correlation function will replace the waveform stored in the 5480A memory segment selected by switches 3 and 2. This routine may not be used to cross correlate waveforms using more than 500 points.

3-135. Add

3-136. This routine adds two 5480A memory segments and stores the sum. When switch 6 (G) of the SWITCH REGISTER is set to zero, the sum replaces the waveform stored in the 5480A memory segment selected by switches 5 and 4 (C), see Table 3-2. If switch 6 is set to one, the sum replaces the waveform stored in the 5480A memory segment selected by switches 3 and 2.

3-137. Subtract

3-138. This routine subtracts two 5480A memory segments and stores the difference. In this routine a 5480A memory segment selected by switches 5 and 4 of the SWITCH REGISTER is subtracted from the memory segment selected by switches 3 and 2 of the SWITCH REGISTER. If switch 6 is set to zero, the difference replaces the waveform stored in the memory segment selected by switches 5 and 4. With switch 6 set to one the difference replaces the waveform stored in the memory segment selected by switches 3 and 2.

3-139. Transfer

3-140. This routine permits the transfer of data from the memory segment selected by switches 3 and 2 (B) into the memory segment selected by switches 5 and 4 (C), see Table 3-2.

3-141. SYSTEM TURN-ON

3-142. Computer Turn-on

3-143. It is important that the computer be turned on and off in the proper sequence to guarantee best operation of the 5481A System. The following sequence of steps should be used when turning the 5481A System ON.

a. Turn Computer ON.

b. Load 5481A System tape as described in Paragraph 3-163.

c. Set SWITCH REGISTER to 000002_8 (starting address of the 5481A System tape).

d. Press LOAD ADDRESS.

e. Press PRESET.

f. Press RUN.

g. The computer will HALT with 102050_8 in the T (MEMORY DATA on 2114A) register. The computer portion of the 5481A System has now been initiated and is ready for use.

h. Turn on the 5480A Signal Analyzer and other peripheral devices.

i. The entire 5481A System is now ready for use. Refer to Paragraph 3-161 for operating modes and procedures. Be sure the LOADER switch (2115A and 2116B Computers) is set to PROTECTED except when loading a program into the computer. When the system is running on standby for any length of time it is best to turn the Teleprinter OFF. This will decrease the wear on the Teleprinter (the 2752A Teleprinter should not be operated more than 5 hours a day maximum).

3-144. 5480A Signal Analyzer Turn-on

3-145. Connect input signals and any auxiliary equipment to the 5480A Signal Analyzer. Input/Output signal specifications and typical set ups are given in the 5480A Operating Manual. Operating instructions and indications in Paragraph 3-146 are for standard Signal Analyzer systems with no auxiliary equipment connected to J15, 16, 17 or 18 (on the rear panel). Operating instructions for systems with connections to these connectors are contained in the manuals for the auxiliary equipment.

3-146. Set controls as follows:

a. FUNCTION to AVERAGE.

b. PRE-ANALYSIS DELAY and POST-ANALYSIS DELAY to 0 and OFF, respectively.

c. Channel A DISPLAY to DATA.

d. Channel B DISPLAY to OFF.

e. Turn POWER switch ON. ON lamp and PROCESS STOP lamp will light.

f. Press OUTPUT-DISPLAY button. Button will light and display will appear on CRT. Observe CRT display for each of the following: Channel A display switch positions; FULL; HALF 3, 4; HALF 1, 2; QUARTER 1; QUARTER 2; QUARTER 3, and QUARTER 4. Display for each setting represents what was in that portion of memory when Signal Analyzer was turned off. If memory section being displayed is not important, erase it by pressing both CLEAR DISPLAY pushbuttons simultaneously; a QUARTER or HALF of the memory can be erased independently with other memory sections.

3-147. Turning 5481A System OFF

a. Turn 5480A Signal Analyzer off.

b. Turn Teleprinter and other peripherals off.

c. Make sure that computer is in the HALT mode.

d. Turn computer power OFF.

e. This procedure will guarantee that the system can be turned back on without having to reload the program.

3-148. 5480A AVERAGE MODE OPERATION

3-149. Description

3-150. The 5480A Signal Analyzer performs either weighted or calibrated averaging. Display resembles oscilloscope presentation of input signal, with noise averaged out. Up to 60 dB signal to noise ratio improvement can be obtained. Vertical display is calibrated in V/cm, noisy signal appears at full value and noise is gradually removed, leaving only signal.

3-151. Set controls as follows:

a. FUNCTION to AVERAGE.

b. SENSITIVITY MULTIPLIER to AUTO.

c. SWEEP NUMBER to 6.

d. PRESET/NORMAL to NORMAL.

e. Channel A and Channel B DISPLAY to DATA (or OFF, if Channel is not used).

f. Channel A and Channel B MEMORY SELECTOR as desired.

(1) Larger memory sections provide more signal resolution.

(2) The processed signal can be stored in one memory section while processing is done in another section.

(3) If MEMORY SELECTOR controls are set to feed A and B to same quarter section of memory, A supersedes B.

(4) Signal processing occurs only: 1) in memory sections selected by MEMORY SELECTOR switches, 2) when PROCESS-START button is lighted, 3) when sync signal is received by the 5486A Control Plug-in.

g. Clear display by simultaneously pressing both CLEAR DISPLAY buttons. OUTPUT-DISPLAY button will light and CRT will display a horizontal line.

h. Press PROCESS-START button. Button will light, and OUTPUT-DISPLAY light will go out. CRT display will show signal processing.

i. If necessary, select TRIGGER SOURCE and adjust LEVEL to initiate processing. Ordinarily, best triggering is obtained using an external triggering source having the same frequency as the signal to be observed.

j. Adjust SWEEP TIME for best display of input signal. Press both CLEAR DISPLAY buttons and PROCESS-START button whenever SWEEP TIME setting is changed.

k. Adjust SENSITIVITY for each displayed input channel to provide best CRT display of input signal.

l. Use POSITION controls to separate or center signals vertically.

m. The above procedure provides a means for obtaining a rough measurement of signal amplitude and frequency, and positioning display. Information in the following paragraphs enables refinement of measurement.

3-152. Signal-to-Noise Ratio Improvement vs. Response to Input Signal Changes

3-153. Signal-to-noise ratio improvement can be determined approximately by SWEEP NUMBER setting, and can be expressed in dB as 3N, where N is sweep number. For example, where N is 0, signal-to-noise ratio improvement is 30 dB (after 2^N or 1024 sweeps).

3-154. Higher SWEEP NUMBER settings result in greater signal-to-noise ratio improvement.

3-155. Lower SWEEP NUMBER settings enable faster response to input signal changes or changes in control settings when PRESET/NORMAL switch is set to NORMAL.

Note

To prevent invalid readings the following SWEEP NUMBER and SWEEP TIME combinations should not be used:

SWEEP TIME	SWEEP NUMBER
1 msec/cm	19 (PRESET) see Note under NORMAL vs PRESET
2 msec/cm	19, 18
5 msec/cm or slower	19, 18, 17, 16

3-156. NORMAL vs PRESET

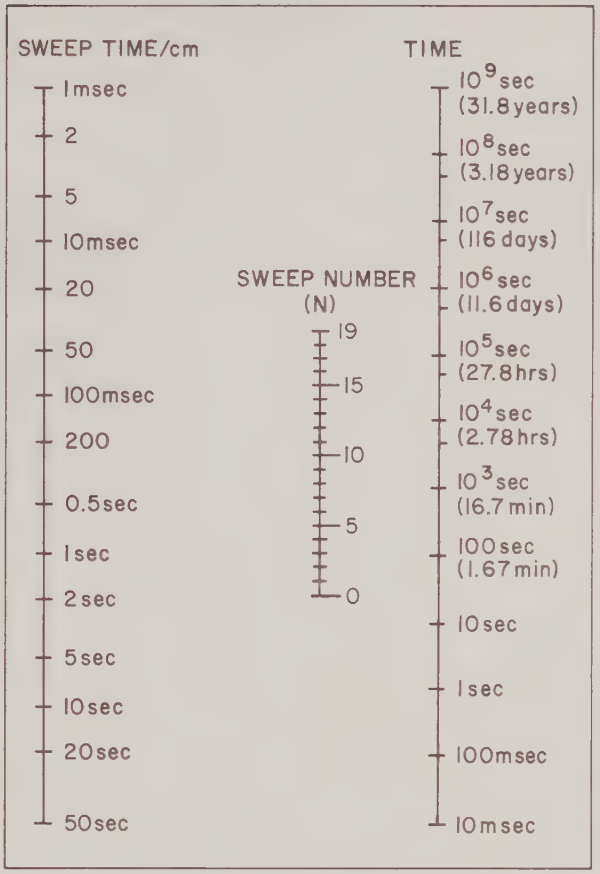
3-157. NORMAL: Signal Analyzer averages all sweeps until it completes 2^N sweeps. After this number of sweeps is completed the averaging process continues except the previous information is weighted exponentially with a time constant equal to the time required to take 2^N sweeps. Averaging continues until PROCESS-STOP (no CRT display) or OUTPUT-DISPLAY is pressed.

3-158. PRESET: Signal Analyzer averages all sweeps until it completes 2^N sweeps (except for N = 19 in PRESET, N = 19 and N = 18 are the same, 5480A sweeps for 2^{18} sweeps, then displays result). After this number of sweeps is completed the averaging process stops and the Analyzer automatically switches to OUTPUT-DISPLAY mode. The value of 2^N increases very rapidly (see Table 3-1), and large values of 2^N can result in very long experiment times. A nomograph (Figure 3-11) is provided to enable approximations of experiment length from PROCESS-START to OUTPUT-DISPLAY. As with NORMAL, averaging process can be stopped at any time by pressing PROCESS-STOP or OUTPUT-DISPLAY. The nomograph does not include any allowance for 5480A "dead-time", so actual experimental length may be up to 100% longer than estimated. Any PRE-ANALYSIS DELAY or POST-ANALYSIS DELAY should be added to SWEEP TIME line and included in overall experiment length.

3-159. CRT Display

3-160. Signal is displayed full scale and noise is reduced with each sweep. Vertical calibration for displayed channel is determined by SENSITIVITY V/CM control. Horizontal calibration is determined by SWEEP TIME and MAGNIFIER switches. In OUTPUT-DISPLAY, vertical display can be expanded by changing setting of SENSITIVITY MULTIPLIER. VERNIER of displayed channel provides for uncalibrated reduction in display size (does not affect input SENSITIVITY).

Figure 3-11. Time to Preset (Nomograph)



3-161. OPERATION OF 5481A SYSTEM TAPE

3-162. With the 5480A Signal Analyzer set up in the Averaging mode (as described in Paragraphs 3-148 through 3-160) it is now ready to provide the computer with data to be processed. Load the system tape into the computer as described below and refer to Paragraphs 3-101 through 3-140 for operation of various system tape routines.

3-163. Loading Paper Tape

3-164. Turn on computer as described under Paragraph 3-142, Computer Turn-on. Use the appropriate procedure below and load tape into the computer.

3-165. TELEPRINTER TAPE READER. See Figure 3-12 for 2752A and 2754A.

a. Set the Teleprinter LINE-OFF-LOCAL switch to LINE.

b. Place tape to be loaded into the reader as shown, and set tape reader switch to START (on 2752A) or RUN (on 2754A).

c. Set the computer SWITCH REGISTER to the starting address of the Basic Binary Loader (e.g., 007700 for 4K memory, 017700 for 8K memory).

d. Press LOAD ADDRESS.

e. Set LOADER switch to ENABLED. (On 2114A, press LOAD and PRESET simultaneously.)

f. Press PRESET.

g. Press RUN.

h. When the tape is loaded the computer should HALT with 102077 in the T register (MEMORY DATA register on 2114A). If the contents of the register are correct set the LOADER switch to PROTECTED and rewind the tape. If the T register does not contain 102077, the tape may have been loaded incorrectly and must be reloaded. If the computer continues to HALT with an incorrect number in the T (MEMORY DATA) register it is possible that the Basic Binary Loader program has been written over (erased). Refer to Paragraph 3-167 for instructions on reloading the Basic Binary Loader.

i. Set the SWITCH REGISTER to 000002_8.

j. Press LOAD ADDRESS.

k. Press PRESET.

l. Press RUN.

The system tape is now loaded and running in the computer.

3-166. 2737A PHOTOREADER. See Figure 3-12.

a. Set POWER switch to ON.

b. Load paper tape into the photoreader as shown in Figure 3-12 with the small feed holes nearest the panel. The first data frames must be to the left of the read element. The tape leader must pass under the hairpin on the read element and between the rollers on the right.

c. Set SWITCH REGISTER to starting address of Basic Binary Loader (e.g., 007700 for 4K memory, 017700 for 8K memory).

d. Press LOAD ADDRESS.

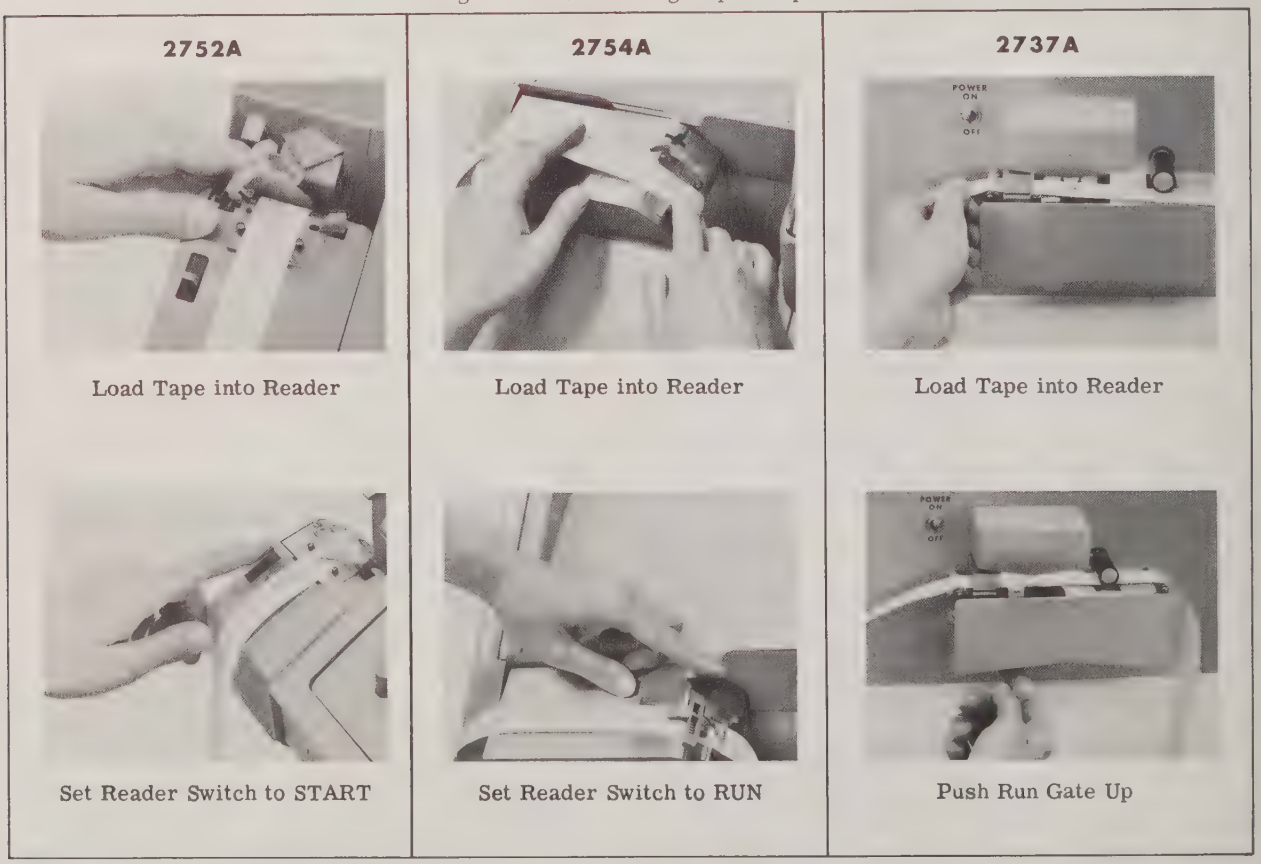
e. Set LOADER switch to ENABLED (on 2114A press LOAD and PRESET simultaneously).

f. Press PRESET.

g. Press RUN.

h. When tape is loaded Computer should HALT with 102077_8 in the T register (MEMORY DATA register on 2114A). If the contents of the T (MEMORY DATA) register are correct, set the LOADER switch to PROTECTED and rewind the tape. If the T (MEMORY DATA register contains another number the program

Figure 3-12. Loading Paper Tape



may have been incorrectly loaded and must be reloaded. If the computer continues to HALT with another number in the T (MEMORY DATA) register, it is possible that the Basic Binary Loader program has been written over (erased). Refer to Paragraph 3-167 for instructions on reloading the Basic Binary Loader.

i. Set the SWITCH REGISTER to 000002_8.

j. Press LOAD ADDRESS.

k. Press PRESET.

l. Press RUN.

The system tape is now loaded and running in the computer.

3-167. RELOADING THE BASIC BINARY LOADER

3-168. If the computer input device (2752A, 2754A Teleprinter or 2737A Photoreader) will not accept a program tape or if incorrect HALT conditions are indicated by the T (MEMORY DATA register on 2114A) register, it is possible that some or all of the loader program has been erased. Before assuming this is the case, however, check for dirt or other foreign material in the input device which may be causing incorrect operation. To reload the loader program follow the directions below which apply to your system.

3-169. Before reloading the loader find out the channel number of the input device (Teleprinter or photoreader) from the insert sheet supplied with this manual. The channel number is used when reloading the loader program.

Note

If your system contains a Teleprinter and a photoreader use the channel number of the photoreader when the channel number of the input device is called for in the loading procedure below. To verify the Basic Binary Loader instructions in memory proceed as follows.

a. Set SWITCH REGISTER to address of desired instruction (Table 3-8 illustrates how to determine the address of an instruction).

b. Press LOAD ADDRESS.

c. Set LOADER switch to ENABLED (located behind front panel on 2114A, see Figure 3-5).

d. Press DISPLAY MEMORY; the contents of the location specified is displayed in the T register (MEMORY DATA register on 2114A). Each time DISPLAY MEMORY is pressed, the next consecutive memory location is displayed.

e. Set LOADER switch to PROTECTED when all desired locations have been displayed.

3-170. To enter an instruction for the Basic Binary Loader:

a. Set SWITCH REGISTER to address of instruction to be entered.

b. Press LOAD ADDRESS.

c. Set LOADER switch to ENABLED.

d. Set SWITCH REGISTER to value of instruction.

e. Press LOAD MEMORY.

f. Set LOADER switch to PROTECTED.

3-171. To load the entire Basic Binary Loader, proceed as follows:

a. Set SWITCH REGISTER to starting address of Basic Binary Loader (e.g., 007700 for 4K memory, 017700 for 8K memory).

b. Press LOAD ADDRESS.

c. Set LOADER switch to ENABLED (located behind front panel on 2114A, see Figure 3-5).

d. Set SWITCH REGISTER to value of first instruction (refer to Table 3-8).

e. Press LOAD MEMORY.

Table 3-8. Instructions for Basic Binary Loader

						0m7735 address ↓		
Address	0	1	2	3	4	5	6	7
0m7700:	107700	063770	106501	004010	002400	006020	063771	073736
0m7710:	006401	067773	006006	027717	107700	102077	027700	017762
0m7720:	002003	027712	003104	073774	017762	017753	070001	073775
0m7730:	063775	043772	002040	027751	017753	044000	000000	002101
0m7740:	102000	037775	037774	027730	017753	054000	027711	102011
0m7750:	027700	102055	027700	000000	017762	001727	073776	017762
0m7760:	033776	127753	000000	1037cc	1023cc	027764	1025cc	127762
0m7770:	173775	153775	1n0100	177765	000000	000000	000000	000000

cc = channel number of Punched Tape Reader
m = 1 for 8K memory
= 0 for 4K memory
n = 6 for 8K memory
= 7 for 4K memory

f. Set SWITCH REGISTER to value of next sequential instruction.

g. Press LOAD MEMORY.

h. Repeat steps f and g until all 64 instructions have been loaded.

i. Set LOADER switch to PROTECTED.

3-172. WAVEFORMS

3-173. Figure 3-13 shows waveforms obtained using the various system tape routines and the CALIBRATOR signal from the 5480A Signal Analyzer. These waveforms may be used to verify proper operation of the system. With the system set-up and operating, proceed as follows (it is assumed that the 5480A is set-up in the Averaging mode as described in Paragraphs 3-148 through 3-160):

a. Connect CALIBRATOR signal to INPUT A connector and set 5480A controls as described below.

b. SWEEP TIME to 10 ms/cm.

c. TRIGGER SOURCE to INTERNAL.

d. SWEEP NUMBER (2^N) to 3.

e. PRESET/NORMAL to PRESET.

f. Set Channel A controls as follows:

1) DISPLAY to DATA (set Channel B DISPLAY to OFF).

2) Press both CLEAR DISPLAY buttons and adjust POSITION control to center base line vertically on graticule.

3) MEMORY SELECTOR to QUARTER 1.

4) SENSITIVITY to .5 V/CM (VERNIER to CAL).

5) DC/GND/AC to DC.

6) POLARITY to UP+.

7) ALT A+B to ALT.

g. Press PROCESS-START. The 5480A will average 2^3 (8) sweeps and switch to the OUTPUT-DISPLAY mode. The CALIBRATOR signal will now be displayed on the Memory/Display Unit CRT, see Figure 3-13.

h. Call the system tape routines from the SWITCH REGISTER according to Table 3-2 (see Paragraphs 3-101 through 3-140 for details) and observe that CRT display is as shown in Figure 3-13.

Note

For Integrate and Differentiate routines, set SENSITIVITY to 2 V/CM.

For Cross Correlation routine, set SWITCH REGISTER switches:

6 to one
4 to one
1 to one

Store CALIBRATOR signal in QUARTER 1 and 2 of the 5480A and set MEMORY SELECTOR to QUARTER 1.

For the ADD and SUB routines, set SENSITIVITY to 1 V/CM, store CALIBRATOR signal in QUARTER 1 and 2 of the 5480A and set SWITCH REGISTER switches:

6 to one
4 to one
1 to one

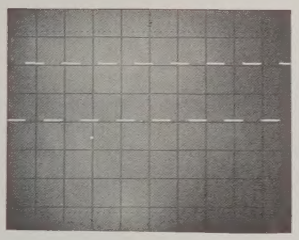
Set MEMORY SELECTOR to QUARTER 1.

For Transfer routine, set SENSITIVITY to 1 V/CM, store CALIBRATOR signal in QUARTER 1 and 2 of the 5480A and set SWITCH REGISTER switches:

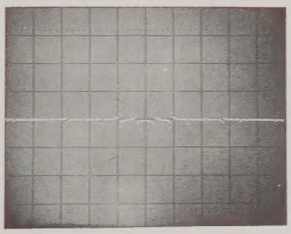
4 to one
1 to one

Set MEMORY SELECTOR to QUARTER 2.

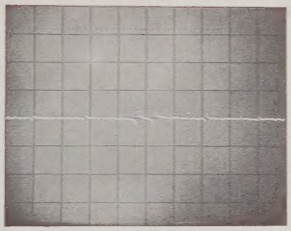
Figure 3-13. Waveforms



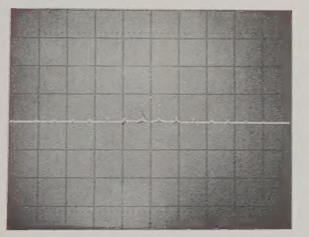
1 Calibrator



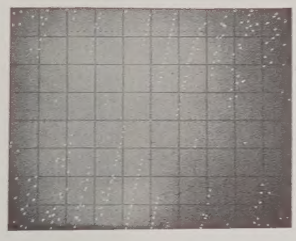
2 Fourier - Real Part



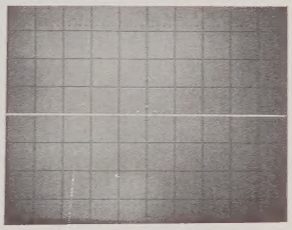
3 Fourier - Imaginary Part



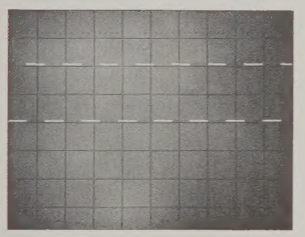
4 Fourier - Magnitude



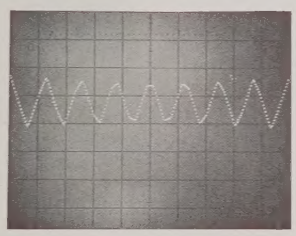
5 Fourier - Phase



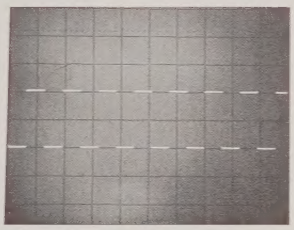
6 Fourier - Power Spectra



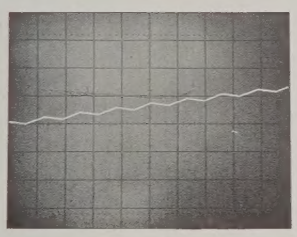
7 Fourier Inverse



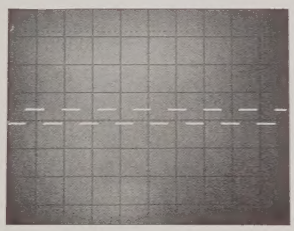
8 Auto Correlation



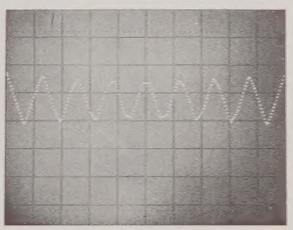
9 Remove DC Component



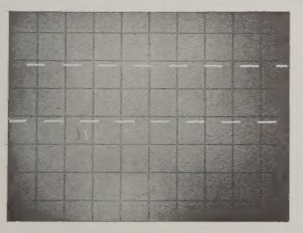
10 Integrate



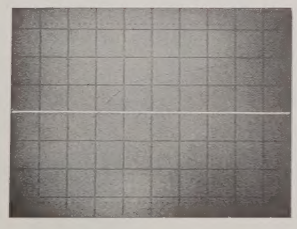
11 Differentiate



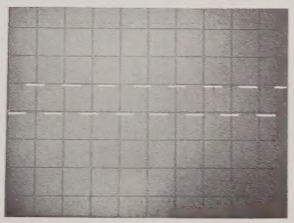
12 Cross Correlation



13 Add B + C → C



14 Sub B - C → C



15 Transfer B → C

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